MODELING COMPUTATIONAL DYNAMICS OF JOB INTERVIEW CANDIDATE'S MENTAL STATES USING COGNITIVE AGENT BASED APPROACH

AJOGE NASEER SANNI

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Universiti Utara Malaysia

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Abstrak

Sokongan untuk temu duga kerja adalah domain yang boleh mendapat manfaat daripada penyelidikan mengenai sistem AI peka-manusia. Model keadaan kognitif yang dibina dapat memberi kesedaran tentang tingkah laku yang ditemuduga sebagai mekanisme untuk proses sokongan pintar. Pembentukan interaksi membina keberkesanan diri, motivasi dan kebimbangan telah dihipotesiskan untuk menentukan keadaan mental seseorang yang ditemuduga. Walau bagaimanapun, pembinaan ini tidak disepadukan, diformalkan dan dinilai untuk kerumitan dinamik mereka dalam kajian terdahulu dan tidak dapat dilaksanakan sebagai komponen penaakulan dalam sistem yang peka-manusia. Kajian ini telah membangunkan model agen kognitif sebagai asas kepada mekanisme cerdas untuk sistem bimbingan temuduga. Model ini menggabungkan tiga konstruk; keberkesanan diri, motivasi dan kerisauan. Setiap konstruk dibentuk sebagai model agen entiti dan kemudiannya disepadukan. Reka bentuk Proses Penyelidikan Sains Reka Bentuk dan Metodologi Pemodelan Berdasarkan Agen telah digunakan untuk menjalankan kajian ini. Interaksi faktor dan hubungan bertindih telah digunapakai untuk mengintegrasi konstruk yang dicadangkan. Model ini diformalkan menggunakan teknik Persamaan Pembezaan Biasa dan kemudiannya disimulasikan. Kes yang dibuktikan telah disahkan dengan analisis kestabilan dan teknik pengesahan logik automatik. Untuk pengesahsahihan model, seramai 36 orang pelajar sarjana dikaji dalam satu percubaan temubual. Keputusan yang diperoleh daripada simulasi model kemudiannya dibandingkan dengan eksperimen manusia. Penilaian adalah berdasarkan teknik statistik iaitu Hotelling T^2. Hasil simulasi telah mengesahkan beberapa pola seperti yang dikenal pasti dalam kesusasteraan domain. Corak tingkah laku setiap model agen serta model bersepadu selaras dengan tingkah laku dinamik calon yang diharapkan dalam situasi temu bual. Keputusan dari pengesahan menunjukkan bahawa tidak terdapat perbezaan yang signifikan (iaitu nilai: ρ kerisauan = 0.391, efikasi diri = 0.128 dan motivasi = 0.466) antara eksperimen simulasi dan manusia. Secara teorinya, dengan adanya tiga konstruk yang dicadangkan, model cadangan dapat mewakili tingkah laku manusia yang lebih baik dalam temu bual. Secara umumnya, dengan memformalkan model tersebut, ia boleh menentukan ciri dinamik secara terperinci. Model kognitif bersepadu ini dapat berfungsi sebagai platform untuk mereka bentuk sistem yang peka-manusia yang memahami keadaan mental pengguna semasa sesi temuduga pekerjaan.

Kata kunci: Pemodelan komputasi, Model berasaskan agen, Keadaan mental calon yang ditemuduga

Abstract

Support for job interview is a domain that can benefit from the research on human-aware AI systems. A developed cognitive model provides the awareness of interviewee behaviours as a mechanism for intelligent support processes. The interplaying constructs of self-efficacy, motivation and anxiety has been hypothesized to define the mental states of an interviewee. However, these constructs have not been integrated, formalized and evaluated for their dynamic intricacies in previous studies hence cannot be implemented as the reasoning component in human-aware system. This study has developed a cognitive agent model as a basic intelligent mechanism for interview coaching systems. The model integrates three constructs; self-efficacy, motivation and anxiety. Each of the constructs is formalized as an entity agent model and then integrated. Design Science Research Processes framework and Agent Based Modelling methodology were used to conduct this study. Factors interaction and overlapping relationship approach was adopted to integrate the proposed constructs. The model is formalized using Ordinary Differential Equation technique and later being simulated. Generated cases were verified with stability analysis and automatic logical verifications techniques. For model validation, 36 undergraduate students were studied in a mock interview experiment. The results generated from the model simulation were then compared against human experiment. The evaluation was based on a statistical technique namely Hotelling's T^2. The simulation results have confirmed a number of patterns identified in the domain literature. The behavioural patterns of the agent models conform to the expected behavioural dynamics of candidate in interview situation. Results from the validation showed that there is no significant difference (i.e. ρ values: anxiety = 0.391, self-efficacy = 0.128 and motivation = 0.466) between the simulation and human experiments. Theoretically, by integration of the three constructs, the model could better represent the mental state of candidates in interviews. In general, by formalizing the model, it can define the dynamic properties in details. The integrated cognitive model serves as a platform for designing a human-aware system that understands the behavioural intricacies of the user during job interview sessions.

Keywords: Computational modelling, Agent-based models, Interviewee mental state, Human-aware system.

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Glossary of Terms

Agent: a discrete entity with its own goals and behaviours, which is autonomous in nature to adapt and modify its behaviours. Each of the construnct is modelled as an entity inform of an agent that can communicate with its environment. The three agent models are unified into an integrated cognitive agent model.

Domain: This is used to refer to the area of coverage or the application of study which is a stretch in human and social psychology, computer science, artificial intelligence and human-aware AI. Domain theories are the related theories in the field of psychology and cognitive science used to define the constructs. Domain model is the identified constituent factors and relationships of the factors for each of the constructs from the domain theories and concepts.

Mental State: a hypothetical state that corresponds to thinking and feeling, and consists of a collection of mental representations and propositional attitudes. This state is represented in the study by the intertwined factors of the constructs of self-efficacy, motivation and anxiety.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Artificial Intelligence (AI) technologies are becoming more robust and reliable hence they are being implemented in different domains to solve complex problems such as in education, transportation, health, stock, and banking (Mohan, Venkatakrishnan, Bobrow, & Pirolli, 2017). The pervasiveness of the AI technologies in our everyday lives is further strengthened by the human-aware component of the intelligence. Several communities in AI – social robotic (Fasola & Matarić, 2013; Fridin, 2014; Guzzi, 2015; Leite, Martinho, & Paiva, 2013; Wainer, Dautenhahn, Robins, & Amirabdollahian, 2014), conversational agents (Hoque, 2015; Rossen & Lok, 2012; Sia, Halan, Lok, & Crary, 2016; Wrobel et al., 2013), and personal assistive systems (Hayes et al., 2015; LeRouge, Dickhut, Lisetti, Sangameswaran, & Malasanos, 2016) have addressed some of the questions that have dominated AI research. These research directions in interactive agent development have been successful through achievements in physical embodiment, verbal and non-verbal behaviour scripting, emotion and gesture understanding in human spaces. However, the aspect of a human-aware AI-modeling and reasoning about human decision making and behaviour is still critical challenges to explore in different application domains (Mohan et al., 2017). In order to be more adaptive and synergistically working with humans, the AI systems must include aspects of intelligence, such as emotional, cognitive or social, to assist humans achieve in a given terrain. Therefore, designing such human-aware systems for the domain of interest involves modeling the mental states of the humans in order to identify their desires and intentions (Bosse, Memon, & Treur, 2011; Narayanan, Zhang,

& Kambhampati, 2015; Nunes & Luck, 2014), providing proactive supports (Chakraborti, Zhang, Smith, & Kambhampati, 2016; Zakershahrak, Sonawane, Gong, & Zhang, 2018), revealing rational behaviours (Fernandes, Custodio, Alves, & Fisher, 2017), providing logical justifications and stimulating trust (Khalid, Wei Shiung, Bin Sheng, & Helander, 2018) based on changes in human physiological, cognitive and affective states.

In the area of job selection, an interviewing process is one of the popular selection techniques to evaluate candidates' qualifications for available position in an organization (Levashina, Hartwell, Morgeson, & Campion, 2014). Job seekers accept employment interview as fundamental to obtaining gainful employment (Diekmann & König, 2015; Huffcut, 2011), and they perceive it as a fairer method compared to other means of selection techniques (Feiler & Powell, 2015). Thus, ability to perform well during an interview process is one of the most critical determinants of graduate employability Furbish (2013). Without that skill, it limits candidates to showcase their talents during interviews, hence reducing their chances to get hired despite of potentials and talents (Malhi, 2011). As a consequence, employment interview issue has attracted researches as the global labour market becomes more competitive for job seekers due to the volatility of current global economy.

According to International Labour Organization (ILO), the uneven economic recovery and poor growth since the world's financial crash of 2008 have continued to hamper employment situations all over the world (ILO, 2017b). The global unemployment rate has remained high. It rose from 3.4 percent in 2016 to 5.8 percent in 2017 implying a total number 201.1 million of unemployed working population. The pace of labour force growth still outstrips employment creation thus results in an additional 2.7 million unemployed people in year 2018. Importantly, the proportion of young people neither in employment nor in education or training (NEET) has also continued to rise (Anderson et al., 2013). The global youth unemployment rate has reached about 13.1 percent, almost three times that of adults' which is indeed a historical peak (ILO, 2017a). Table 1.1 shows the unemployment trends.

Table 1.1

Unemployment Trends and Projections, 2007-2018

Country grouping	Unemployment rate, 2007–18 (percentages)				Unemployment, 2016–18 (millions)		
	2007–2015	2016	2017	2018	2016	2017	2018
WORLD		**5.7**	**5.8**	**5.8**	**197.7**	**201.1**	**203.8**
Developed countries		6.3	6.2	6.2	38.6	37.9	38.0
Emerging countries		5.6	5.7	5.7	143.4	147.0	149.2
Developing countries		5.6	5.5	5.5	15.7	16.1	16.6

Source: *(ILO, 2017b)*

In order for new graduates to enter workforce, many activities are usually organized such as social coaching workshops, counselling programs, internship, and site visits. For example, in Chang et al., (2012), the mock interviews were analysed as a good way to prepare candidates to face the interviewing process. In addition, several studies have shown the contribution of previous interview experience and interview coaching to interviewee states and overall interview skills (Tross & Maurer, 2008; Huffcutt, van Iddekinge, & Roth, 2011). This is the precursor to explain how a mock interviewing or interview coaching process influences the interviewing outcomes (Callejas, Ravenet, Ochs, & Pelachaud, 2014).

Thus, the technological solutions in the form of intelligent training systems and embodied conversation agents have been adopted in several computer-based interview coaching system, such as in Anderson et al. (2013), Hoque, Matthieu, and Martin (2013), Kwon, Powell, and Chlmers (2013), Naim, Tanveer, Gildea, and Hoque (2018), and Subri (2014).

The inherent behavioural differences of interviewees which manifest in a number of reactions such as physiological responses (e.g. blood pressure, increase in heart rate), cognitive responses (e.g. reduced attention, forgetfulness) and emotional responses (e.g. nervousness, irritation) are main important factors in interview process related to the performance (Huffcut, 2011). Those behaviours were influenced by the mental states (defined by self-efficacy, motivation, and anxiety) during interviews. Sometimes, these constructs can result to very destructive and devastating stress conditions (Huffcutt et al., 2011; Juster, Perna, Marin, Sindi, & Lupien, 2012). For example, it affects the cognitive and emotional stability of the job seeker that results to poor ratings by the interviewers (Huffcutt, van Iddekinge, & Roth, 2011). Therefore, the domain requires a coaching technology that is knowledgeable about a wide range of behavioural interventions and how they influence an interviewee through the development of a formal model of a human functioning process.

Thus, through the development of a formal model about human behaviour or cognition, it helps researchers to recognise important processes within observed domain. One of the main reasons a computer model is a good choice is due to the fact that verbally expressed theories or concepts are sometimes flawed by internal inconsistencies, logical contradictions, and theoretical weaknesses (Fum, Del Missier, & Stocco, 2007; Keller, 2015; Vancouver, Tamanini, & Yoder, 2010). While theoretical concepts aim to explain basic conceptual interplays about human behaviours or cognitive processes, the formal models are aiming to explain the underlying mechanics and temporal dynamics of those processes (Jia et al., 2017; Vancouver, Weinhardt, & Vigo, 2014). In the end, the results from the simulated model could be viewed as a tool to strengthen the underlying theories in the domain or as a computational engine to be integrated into a human-aware system that is capable in providing support for human activities (Mohan et al., 2017; Vancouver & Weinhardt, 2012).

With the aforementioned concepts, this study leverages the conceptual model for understanding applicants' behaviours in employment interviews by Huffcutt et al (2011), as a benchmark model for an interviewee states influence construct (interviewee mental state). The constructs of self-efficacy, motivation and self-efficacy have been established to define human mental states leading to behavioural complexities in selected domain as in (Juuso, 2011; Katalin Piniel & Csizer, 2015; Katalin Piniel & Csizér, 2013). In this study, the Social Cognitive Theory (SCT) becomes a central theory that connects other theories and concepts to arrive at the domain model. It emphasizes how cognitive, behavioural, personal, and environmental factors were used to determine motivation and behaviour (Wood & Bandura, 2013). The Design Science Research Process (DSRP) is chosen as an adopted framework to guide the study, while an Agent-Based Modeling (ABM) methodology is used to develop the agent-based cognitive models. There are six stages of DRSP involved. These stages are; 1) problem identification and motivation, 2) objective for a solution, 3) design and development, 4) demonstration, 5) evaluation, and

6) communication (Baskerville, Baiyere, Gergor, Hevner, & Rossi, 2018; Deng & Ji, 2018; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Schorr & Hvam, 2018). Consequently the designed conceptual agent models and integrated cognitive model are formalized using computational science approaches such as First-Order Predicate Logic and differential equation (Li & Chan, 2013; Winkel, 2015).

Later, these simulated dynamics patterns are evaluated using stability analysis, automatic trace language and human experiment (Sargent, 2013; Treur, 2016d). The formalized integrated model can be extended into digital artefacts as a human-aware system to simulate an interview process and gain an appropriate understanding of individual interviewee's behavioural dynamics. In addition, such systems can provide supports by seeking to answer what, when and how to support within the context of the three main factors (self-efficacy, motivation, and anxiety) that define dynamics of interviewee mental states.

1.2 Problem Statement

The acceptability of employment interview by organizations, human resource managers and applicants as a fundamental and fair means of job selection process has attracted many research efforts for decades (Huffcut, 2011; Macan, 2015; Naim et al., 2018; Shenoy & Aithal, 2018). The competitiveness in the labour market occasioned by the volatility of global economy has put pressure in the job candidates that may affect their cognitive, psychological and emotional status both before and during the interview process. For example, inadequate personal behaviours can manifest as a result of complexities from perceived low self-efficacy, anxiety disorder and poor motivation

(Katalin Piniel & Csizer, 2015; Katalin Piniel & Csizér, 2013) and this can affects performance in critical situations such as job interview (Baur, Damian, Gebhard, Porayska-Pomsta, & André, 2013).

To address this issue, a number of institutions have undertaken to set up specialized inclusion centres to coach young people to secure jobs by professional practitioners (Baur et al., 2013). In Malaysia, *Skim Latihan 1Malaysia* (SL1M) is one of the programmes to enhance the employability of young graduates through training on selection interview and employment-related skills (“1Malaysia Training Scheme,” 2015). In addition, several interview training programmes have been designed by psychologists and counsellors to help improve applicants’ interview skills. However, due to obvious constraints like cost, and inconvenience of traveling either by the tutors or the trainees, (Langer, Konig, Gebhard, & Andre, 2016) researchers in intelligent systems designs have explored computer-based techniques for preparing job seekers to experience a better interview performance (Langer et al., 2016). Novel technologies provide a room for new training opportunities that have been neglected, yet cost effective, offer spatial mobility, and big array of user data utilization (Guzzo, Fink, King, Tonidandel, & Landis, 2015; McGregor, Bonnis, Stanfield, & Stanfield, 2015). Projects such as MACH (Hoque et al., 2013), TARDIS (Anderson et al., 2013) and (Naim et al., 2018), and UVIA (Subri, 2014) have provided the implementation frameworks for digital training platform to enhance interview performance. These digital systems are concerned majorly with coaching applicants on the best practices to answer interview questions with a few focusing on verbal and non-verbal social communication cues (Diekmann & König, 2015; Hoque, 2015; Huang, Morency, & Gratch, 2011; Langer et al., 2016; Naim et al.,2018).

The focus on these areas is connected to the salient beliefs that success at interviews is highly dependent on the interviewee's abilities (e.g. cognitive ability, communication skills, attitudes) (Lauren, 2009; Malhi, 2011; Dipboye, Macan, & Shahani-Denning, 2012). However, the individual's behavioural dynamics in employment interviews that may influence the interviewee's performance are yet to be integrated into the digital designs efforts (Huffcutt et al., 2011; Levashina et al., 2014; Naim et al., 2018; Roulin, Bangerter, & Levashina, 2014). Therefore, the implemented frameworks so far are lacking in the aspect of human-aware approach to modeling and reasoning about human decision making and behaviours during interview process. Central to this behavioural tendency is the Interviewee States Influence defined by a set of interview self-efficacy, interview motivation and interview anxiety constructs (Huffcutt et al., 2011). Harnessing the interplaying factors in order to integrate the constructs is an important aspect to identifying the mental framework in human cognition (Katalin Piniel & Csizer, 2015; Katalin Piniel & Csizér, 2013). Therefore, an intelligent coaching system that is capable to predict applicant's behaviour in a simulated interview environment can provide appropriate supports at the right moments and strategies. As a first step in designing a human-aware system with intelligent components to understand these dynamically changing interviewee behaviours, theoretical and analytical models on applicant behaviours in employment interviews need to be developed.

Related models have been attempted in the literature but none of them has achieved a fully formalized cognitive model that integrates the three mental state constructs, for example, in (Azizi, Ahmad, Yusof, Ahmad, & Yusof, 2016; McQuiggan, Mott, & Lester, 2008; Mollee & van der Wal, 2013; Shell & Chiriacescu, 2014; Vancouver & Purl, 2017;

Wang, 2011). Moreover, most of the models are not fully validated to test their conformity with temporal dynamics of the human subjects in an interview related situation.

This study involves a number of theories that underpin the model of interviewee performance from the perspectives of applicant behaviour and states influence. Thus, the models are designed to understand three fundamental constructs within interviewee cognitive processes of self-efficacy, motivation and anxiety. Later, the agent models are combined into an integrated cognitive agent model and evaluated for conformity with behavioural dynamics of job candidates in interview situation. This serves as the platform for designing intelligent artefacts that can explore and analyse applicants' mental states during interviews with a view to providing appropriate supports.

1.3 Research Question

This study will seek to answer the following research questions;

1. What are the related factors from theories that define the individual constructs of self-efficacy, motivation and anxiety
2. How can the related factors formalized into cognitive agent models be integrated to represent the mental state of interviewee?
3. How can the cognitive agent models and integrated model be evaluated within a simulated job interview environment?

1.4 Research Objective

The main objective of this study is to develop a cognitive agent model of interviewee mental states. Specifically, the research intends to achieve the followings;

1. To analyse the inter-related factors from domain theories in self-efficacy, motivation, and anxiety during interview sessions.
2. To develop formal cognitive agent models for the interviewee mental state constructs of self-efficacy, motivation, and anxiety.
3. To integrate the formal cognitive agent models into a unified cognitive agent model that represents an interviewee mental state.
4. To evaluate the designed cognitive agent model within simulated job interview domain.

1.5 Scope of the Study

This study focuses on a formal model of interviewee behaviour based on applicants' interviewee state influence in terms of three important constructs (interview self-efficacy, interview motivation and anxiety) that interact in some ways to influence interviewee behaviour which inadvertently affects their performance. The underlying theories that support the constructs among others are Social Cognitive Theory, Expectancy-Value Theory and Theory of Generalized Anxiety Disorder. These three constructs are formally developed into cognitive agent models using computational modelling approaches (e.g. differential equations and First-Order Predicate Logic). Later, these models were verified using mathematical verification and automated logical trace analysis. For the validation purposes, a total number of 36 final year undergraduate students from Kaduna

Polytechnic, Nigeria, were selected to conduct the human experiment. Later, the obtained datasets were analysed using the Hotelling's T^2 statistical technique.

1.6 Significance of the Study

This research has contributions both in the areas of theory and application. While the theoretical contribution will provide a further understanding of the computational dynamics of interviewee behavioural constructs that affect performance to psychologists and cognitive scientist. It also enhances related computer science research in the domain of intelligent interviewing training system.

1.6.1 Theoretical Perspectives

Theoretically, the study contributes to provide a clear understanding of the dynamics of interviewee states influence. For example the formal analysis of each of the agent model gives credence to the underlying theories upon which they are built. In this case, computational model of the interplay between self-efficacy, motivation and anxiety that define interviewee's behavioural phenomena has not been investigated before. Another important contribution of this study is the integration of the agent models to serve as an intelligent module in a computational framework for a job interview coaching system. This study will narrow many contradictory results from the empirical studies on the interplays between the three distinctive but related psychological constructs of self-efficacy, motivation and anxiety. Moreover, each of the agent and integrated model serves as a tool for developing future theories in the domain of cognitive science.

1.6.2 Application Perspectives

The understanding of human behavioural dynamics in a simulated interview environment using the technique of cognitive modelling provides a platform for an innovative applications and solutions that contribute to an incisive understanding of intelligent systems. Therefore, the integrated model of interviewee mental state constructs is an intelligent module of a computational framework for a human-aware system intended for interview coaching domain. This type of framework will serve as a foundation for designing intelligent systems equipped with an understanding of behavioural characteristics of trainees in job interview coaching. Using this approach, this model could be encapsulated within existing virtual training agents to simulate applicant's mental state in addition to other verbal and non-verbal behaviours the systems are meant to realize.

1.7 Organization

This thesis is organized into seven chapters namely; (i) Introduction, (ii) Literature Review, (iii) Methodology, (iv) Model Development and Integration, (v) Model Simulation, (vi) Evaluation, (vii) Discussion, Conclusion and Recommendation. The details of each chapter are as presented below

Chapter 1: Introduction

The basic concepts and fundamentals of this study are established in this chapter. The background of the research was extensively discussed to develop the problem definition. As a result, the basic research questions were itemized and serve as a grounding to form the research objectives. The scope of the study was defined to provide a boundary for this work. Finally, both theoretical and application contributions from this study were established.

Chapter 2: Literature Review

This chapter presents the theories, concepts, and research work used in this study from four different perspectives. These perspectives are interview domain and conceptualization, technology perspective, computational modelling, and model integration.

Chapter 3: Methodology

This chapter describes the Research Science Design Process (RSDP) as a basis to guide the study. Also, important concepts in an Agent-Based Modeling (ABM) methodology were explained, followed by evaluation techniques for the verification and validation.

Chapter 4: Model Development and Integration

Various theories and concepts that underpin each of the constructs were further analysed in this chapter to form causal relationships (conceptual models) between the interconnected concepts. These conceptual models are further formalized using a set of computational mathematical approaches. The agent models were merged based on identified overlapping and interact relationships into an integrated agent model.

Chapter 5: Model Simulation

In this chapter, the formalized models were converted and implemented in a numerical programming language platform for simulation purposes. Selected identified cases from the literature are used to simulate the projection and progression of certain behaviours.

Chapter 6: Evaluation

This chapter describes the evaluation process of the proposed models. First, the stability analysis and automatic verification of each of the three constituent agent models, as well as the integrated model, were conducted to verify the models. Later, the evaluation for human experiment was conducted for the integrated model to validate the model.

Chapter 7: Conclusion

This final chapter provides a summary of the findings (related to the research objectives) and future work of the study.

1.8 Summary of the Chapter

This chapter provides the foundation of the study by defining the background and problem domains. Insights about the domain, basic questions that will drive the research and the objectives were formulated. Also, the theoretical and application significance and the scope of the study were defined. Next chapter will discuss the concepts and review research works related to the domain.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter is segmented into several sections. The first part (Section 2.1) explores the domain of interview and conceptual framework. Later, Section 2.2 of this part describes relevant constructs in cognitive and behavioural elements involved that affect interview performance. It follows by Section 2.3 that explores various theories related to the domain. Section 2.4 covers aspects in technology for interview coaching. Section 2.5 discusses topics and works related to cognitive science perspectives in interviewing behaviours, while Section 2.6 discusses related works on Agent Based Modeling. In Section 2.7, evaluation methods of formal models are detailed up. Section 2.8 covers the aspect of model integration and finally, Section 2.9 summarizes the chapter.

2.1 Concepts in Employment Interview

An interview process is one of the critical steps in hiring the best candidates for the vacant positions. In this perspective, Malhi (2011) defines an employment interview as ―an organized interaction between an employer and applicant to attain specific goals". It is also a test that involves interaction between the applicant of a job (interviewee) and the representative of the hiring organization (interviewer) where dyadic transaction or a two-way street in a selection process is involved (Malhi, 2011; Dipboye et al., 2012).

Interviews vary according to the way the questions are organized as it can either in form of a free unstructured conversation or a well-organized list of questions for the applicant (structured) (Dipboye et al., 2012). In many cases, structured interviews are widely used to predict better candidates for the designated job (Levashina et al., 2014). There are different types of question in a structured interview. The situational interview questions which are future-oriented in nature and behavioural interview questions that are experience-based (Levashina et al., 2014) were among prominent used approaches. The other notable interview formats are; 1) case interview-where applicants are given situations, problems, or challenge to be solved (Cosentino, 2013), 2) panel interview-where interviewee are interviewed by several panel of stakeholders during the hiring process (Totaljobs, 2016), and 3) stress interview- where candidates are put under different pressure during the process to identify how candidates handle stress (Scivicque, 2013). Recently, technology has changed the medium of the interview and it is not solely limited to face-to-face mode. For example, telephone (Jeske, Shultz, & Owen, 2018; Oliphant, Hansen, & Oliphant, 2008), computer-mediated video charts (Chapman & Rowe, 2002) and web-based modes of interviewing such as Skype and other VoIP technologies (Iacono, Symonds, & Brown, 2016) are being applied by employers especially at the initial stage of the hiring process (Blacksmith, Willford, & Behrend, 2016; Levashina et al., 2014). Whatever types or modes adopted enriches the employer's accurate assessment of candidates to know whether they would be good fits for the vacancy and the organization (Jeske et al., 2018). Thus, this related domain have attracted a series of studies to define the constructs or features from the interviewee that employers are willing to measure (Salgado & Moscoso, 2002; Thorsteinson, 2018).

2.1.1 Interview Measuring Constructs

The importance of employment interview to selecting process is widely recognized. While most organizations accept it as an acceptable means of identifying potential applicants that possess the requisite skills to their organization (Diekmann & König, 2015; Huffcut, 2011), the job seekers believe this is the fairest selection methods (Hausknecht, Day, & Thomas, 2004; Macan, 2015). The meta-analytic approach was used in most cases to determine the constructs measured in an interview. From this analysis, wide varieties of applicants' personal attributes were being captured such as mental capability, knowledge and skills, applied social skills, physical attributes and organizational fits (Hufcutt, Conway, Roth, & Stone, 2001; Shenoy & Aithal, 2018)

For example, Salgado and Moscoso (2002b) a study was carried out to explore the interviewing constructs from two angles, namely conventional and behavioural items. First, the conventional item is related to the general mental ability, grade point average (GPA), job experience and Big Five personality traits (conscientiousness, agreeableness, neuroticism, openness to experience and extraversion). While, the behavioural interviews assess constructs such as job knowledge, job experience, situational judgment, and social skills.

Another study conducted by Macan (2009) has identified cognitive ability, personality traits, job knowledge, job experience, situational judgment, GPA, tenacity-resilience, social skills, emotional intelligence, self-discipline, empathy, cross-cultural awareness and teamwork as the key factors to measure prospective candidates. When the personality is narrowed down, the Agreeableness and Extraversion attributes were frequently measured by successful candidates. In addition, the applicant characteristics such as demographic information (gender, race, age, disabilities, overweight, and pregnancy) and impression management play an important role for the selection constructs. Also, the negative effects from anxiety were reported to have an effect on interviewee performance.

Malhi, (2011) asserted concerns on communication skills, achievement orientation, integrity/honesty, willingness to learn, initiative, the capacity to work as a team player, high self-esteem, problem-solving ability, interpersonal skills, flexibility/adaptability, professional appearance, related experience, ability to multitask, company knowledge and leadership potential as the most important to be evaluated by the interviewers. From these attributes, he found out skill can be improved but not the attitude as it takes time to be changed.

Huffcutt (2011) proposed a theoretical model that posited three sources of construct-related variance in interview ratings. These sources are; job-related content (such as job knowledge), interviewee performance (applicant behaviours which influence rating), and personal/demographic characteristics (potential job-irrelevant interviewer biases). Table 2.1 presents the detailed of the measurable constructs based on those three classifications views.

Table 2.1

Detail Interview Constructs in Three Categories

Job Related Contents	Interviewee Performance	Demographic Characteristics
General traits	**Social effectiveness skills**	**Attractiveness**
Mental ability	Impression management	Race
Personality traits	Social skills	Gender
	Self-monitoring	Similarity in background and attitude
	Relational control	Culture
Experiential Factors	**Interpersonal Expressions**	
Experience	Verbal expressions	
Education	Non-verbal behaviour	
Training		
Job Elements	**Personal Factors**	
Learned knowledge	Training experience	
Skills and abilities	Self-efficacy	
Job motivation	Motivation	

The reviews presented a basic construct to design a coaching programme to produce ideal results. It is worth noting that interviewee performance measured during interviews is highly dependent on personality-related constructs (Dipboye et al., 2012), which shows how applicants really behave during the interview (Huffcutt et al., 2001; Hoque et al., 2013). Therefore, those aforementioned constructs could be used as a basis to design a coaching system targeted to improve interviewee's performances. The considerable amount of research on the interview was focused on interviewer judgments with far less attention paid to characteristics of interviewees that might lead to good performance in the interview (Cook, Vance, & Spector, 2000; Huffcutt et al., 2011). Nevertheless the theoretical framework proposed by Huffcutt et al., 2011 focused on interviewee behaviour with reference to state infuence (mental state) and attributes such as individual interview self-efficacy (Tross & Maurer, 2008), anxiety (Cook et al., 2000; Mccarthy &

Goffin, 2004, Carless & Imber, 2007), motivational influence (Steers, Mowday, & Shapiro, 2015), cultural backgrounds (Banki & Latham, 2010), and interviewer personality (Carless & Imber, 2007; Chen, Wen-Fen Yang, & Lin, 2010) that affect interviewee performance which need exploration.

2.1.2 Interviewee Performance

Interviewee performance during interview processes has received relatively low attention in a myriad of research on job interviews. Much attention have always been devoted to interviewer ratings, which is significant though. However, the possible cause-and-effect chains that define the ratings are significantly overlooked (Huffcutt et al., 2011; Dipboye et al., 2012). For example, the determination of performance solely based on interviewer rating without recourse to individual difference of the applicants could be erroneous as ratings for employees by supervisors are subjective (Naim et al., 2018; Powell, Stanley, & Brown, 2018). This explains why a single employee is rated differently by different supervisors (Heidemeier & Moser, 2009; Oh & Berry, 2009).

The behaviours of applicants during interview contributes to the determination of interviewee performances (Huffcutt et al., 2011, Dipboye et al., 2012). These behaviours can be used to define the individual differences that influence interviewer's rating on individual basis or related to other situational factors, such as interview medium and interviewer disposition (Langer et al., 2016; Levashina et al., 2014).

2.1.3 Interview Coaching

Coaching is one of the prominent approaches for improving interviewee performance (Langer et al., 2016; Maurer, Solamon, & Lippstreu, 2008). The process which aims to regulate the competing goals of interviewers and interviewees is the contexts in which interview coaching can be considered (Tross & Maurer, 2008). It is evidenced in literature that performance of applicants during interview can be enhanced with coaching. Coaching can results to increase interviewee's knowledge, this in turn results in better interview performances (Maurer, Solamon, Andrews, & Troxtel, 2001; Maurer et al., 2008; Tross & Maurer, 2008, Naim et al., 2015). Research has also shown that interviewees tend to have positive feedbacks towards coaching, which is often an underlying goal of any interview process (Maurer & Solamon, 2006). The effects of coaching on interview can be summarized in terms of helping to prepare the applicants to respond appropriately to underlying concerns of the employer, building a strong rapport with the interviewer, learning to portray positive attitudes (e.g., enthusiasm), selling of credentials to the need of the employer, and thoughtful answers and intelligent questionings.

2.2 Theoretical Models in Selection Interview

Recent literatures in selection interviews have emphasized that employment interviews constitute a highly complex and competitive social endeavour involving decisions critical to both interviewees and interviewers (Dipboye et al., 2012; Naim et al., 2015; Shenoy & Aithal, 2018). This part involves how both parties adapt their behaviours in achieving their objectives (Macan, 2015). In order to properly support the theoretical ground for this study, which lies on the interviewee behaviour that influences the interviewer judgment, some fundamental theories and frameworks are explored.

2.2.1 Signalling Theory in Employment Interview

Signalling theory asserts each social situation to involve signalling systems consisting of a sender, a receiver, and a signal which is associated to the sender's observable characteristic in that situation (Connelly, Certo, Ireland, & Reutzel, 2011). In the context of employment interview, Bangerter, Roulin, König and Ko (2012) observed that interviewees have information about their skills and abilities, past failures, or personal goals that are not directly available to the interviewers. Thus, the Signalling Theory improves the understanding of why interviewees and interviewers try to adapt their behaviours to influence each other. For example, Bangerter et al. (2012) have applied the principles of signalling theory to personnel selection process in a framework that defines how to see employment interview processes as a network of dynamic, adaptive relationships between interviewees and interviewers. Both interviewees and interviewers try to detect the interest pattern of their interaction partner so that they can adapt to such behaviours in order to send the correct signals. The other party may in return counter-adapt to these adaptations which can holistically change the signal interpretation and decisions made on them (Melchers, 2015). The centrality of this study is focusing on a general framework for an interview training system that can adapt to trainee's inherent behaviors that affects their performance

2.2.2 The Model of Faking Likelihood in Employment Interviews

Levashina and Campion (2006) conducted a study to examine variety of situational and dispositional variables as the key factors that affect the degree to which people engage in faking during an interview as defined in Figure 2.1. The model asserts that impression management or faking during interview is a function of the respondent's capacity to fake, willingness to fake, and opportunity to fake.

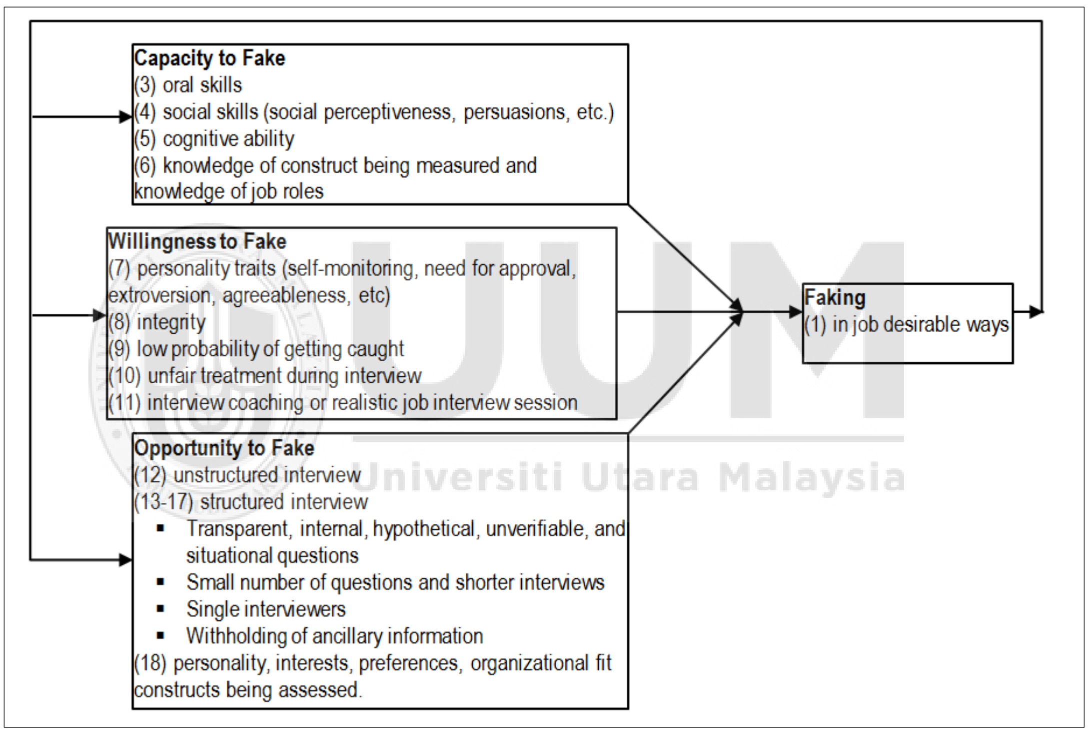

Figure 2.1. The Model of Faking Likelihood in Employment Interviews (Levashina & Campion, 2006).

Capacity to fake involves other capabilities such as cognitive ability, social skills, oral expression skills and knowledge of the construct being measured. For example, willingness to fake represents psychological and emotional characteristics that influence the degree to which candidates are disposed to misrepresent their response during the process of interview. This includes motivation, personality, and interview coaching. On the other perspective, the opportunity to fake includes certain environmental factors that enable or constrains faking, which is not within the direct control of the applicant (such as the type of interview).

2.2.3 A Theory of Self-Presentation in Personnel Selection Settings

The model of self-presentation in personnel selection attempts to understand applicants' self-presentation as goal-directed behaviour whose success hangs on the availability of individual resources (Marcus, 2009). The model is consistent with the faking model but added a few concepts such as resources, hence identifying individual differences in motivation and ability as well as situational factors is considered for understanding applicants' self-presentation. The theory particularly categorizes resources into two distinct sets; self-presentational skills and motivation as depicted in Figure 2.2.

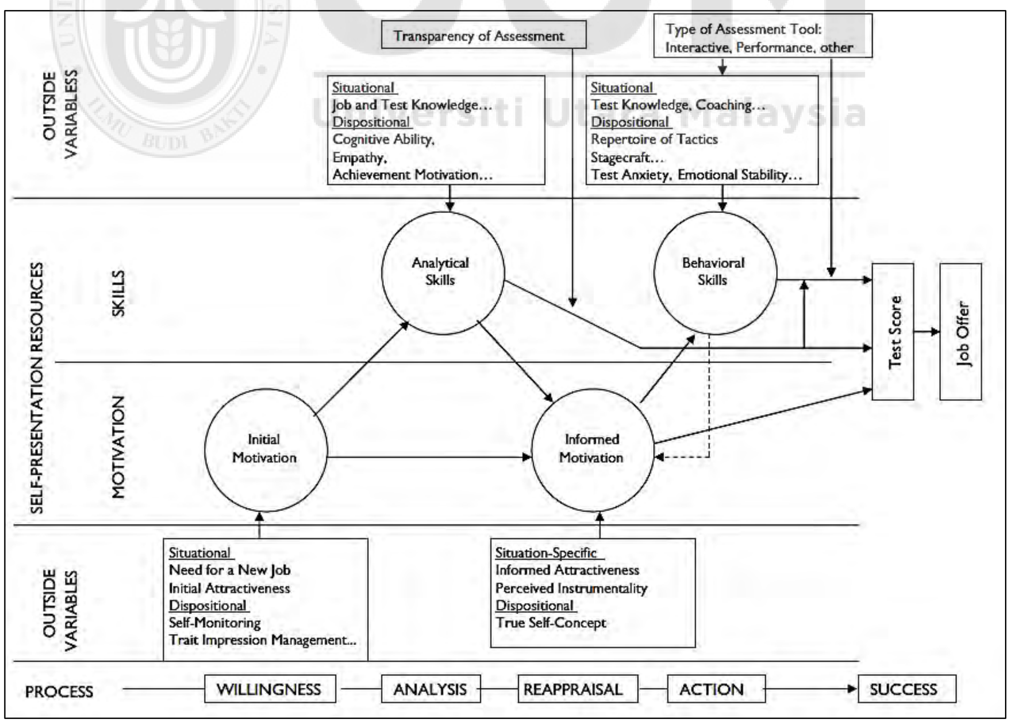

Figure 2.2. A Process Model of Self-presentation in Personnel Selection Settings from the Applicant's Perspective (Marcus, 2009).

The assertion of the theory is that applicants enter the process with an initial willingness to present themselves favourably (motivation upon application for the job). They then proceed by using the analytical skills to analyse the selection situation. The situation appraisal (motivation informed by re-evaluation) which determines the use of specific levels and types of self-presentation (e.g., action using behavioural skills). The motivation state is subject to change the process depending on the kind of information received. The concept of expectancy model of motivation is used by the theory to define its motivation (Marcus, 2009).

Since the current study is on the natural state of the applicants not minding the self-presentations or faking attitudes that may characterize their behaviours during interviews, components from this model could suffice to corroborate the aspect of the Theoretical Model of Interviewee Performance (Huffcutt et al., 2011) adapted for this study.

2.2.4 Behavioural Expression of Interview Anxiety Model

Feiler and Powell (2015) created the Behavioural Expression of Interview Anxiety Model (BEIAM) as a framework to investigate; (1) the behavioural cues that are displayed by interviewees, and trait judgments formed about them, and (2) why anxious interviewees are rated low in interview performance ratings. These two factors are also related to the assertiveness and interpersonal warmth as a mediated relationship between interview anxiety and performance. Figure 2.3 shows the conceptual BEIAM model.

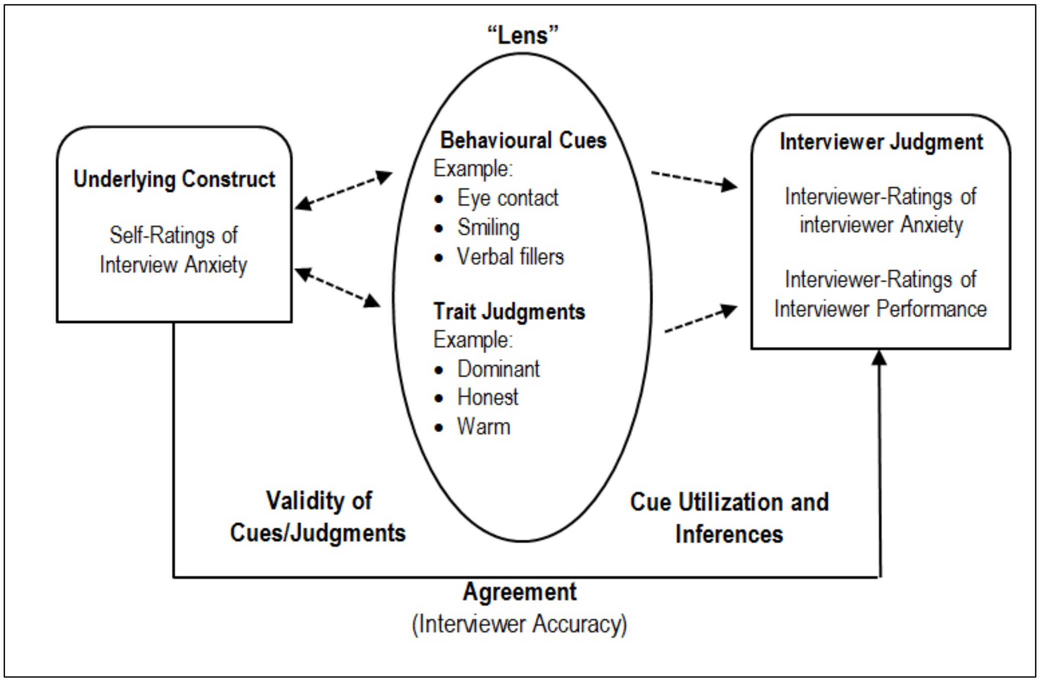

Figure 2.3. Behavioural Expression of Interview Anxiety Model (BEIAM) (Feiler & Powell, 2015).

While this model basically focused on interviewer assessments of the interviewee based on the interviewee's cues and trait, however, a number of defined factors of the model are important for building the causal relations of the entities that make up the domain model of this study.

2.2.5 Theoretical Model of Interviewee Performance

The Interviewee Performance Model as proposed by Huffcutt et al. (2011) (see Figure 2.4) explains interelated factors affecting interviwee behaviours which defines their performance. The complete model in Figure 2.4 presents interviewee performance as a mediating factor between candidate attributes and interviewer ratings.

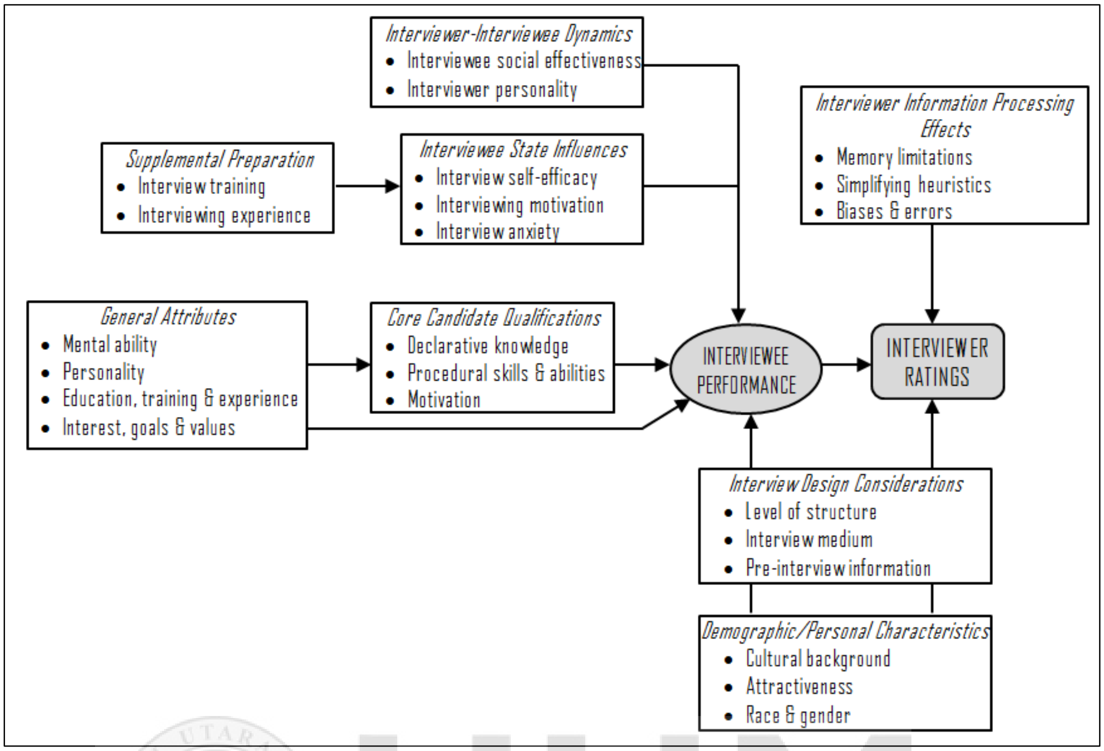

Figure 2.4. Theoretical Model of Interviewee Performance Mediating Between Candidate Attributes and Interviewer Ratings (Huffcutt et al., 2011).

At the core of the model is the interviewee states influence which defines the constructs that are fundamental to behavioural attributes which influence interview performance. These constructs are; 1) *interview self-efficacy* (applicant's perceived belief in his/her ability to do well during the interview) (Wood & Bandura, 2013), 2) *interview motivation* (applicant's drive or desire to participate in an interview process and giving his/her best) (Becton, Feild, Giles, & Jones-Farmer, 2008), and 3) *anxiety* (applicants' experience of unpleasant feeling or nervousness during interview) (Feiler & Powell, 2015). Other critical constructs such as *supplementary preparation* (interview training and experience) and *interviewer-interviewee dynamics* (interviewee social effectiveness and interviewer personality) are environmental and personal factors that trigger interviewee behavioural tendencies that later can influence performance.

Interviewee mental state defined as states influence, serves as the connecting factor and central to the overall behavioural display during the interview. Hence, this conceptual model provides a detailed process and information about the relationship between interviewee mental state and its performances, therefore it is one of the best models to be used in this study.

2.2.6 Summary of the Theories in Selection Interview

The aforementioned theories have been able to particularly show how individualities of interviewee can affect their ratings by the interviewer. The constructs of the related employment interview theories and models discussed above are summarized in Table 2.2.

Table 2.2

Summary of Theories and Models Related to Interviewee Employment Performance.

Theory/Model	Main Constructs	Author(s)
Signal theory in employment interviews	Skills, Abilities, Experience, Personal goals, Interviewer-Interviewee relation.	(Connelly et al., 2011; Bangerter et al., 2012; Melchers, 2015)
The model of faking likelihood in employment interviews	Faking likelihood skills, cognitive ability, knowledge of constructs, personality traits, interviewer disposition	(Levashina & Campion, 2006)
Theory of Self-presentation in personnel selection settings	Skills, motivation, knowledge, cognitive ability, test anxiety, emotional stability, self-concept.	(Marcus, 2009)
Behavioural expression of interview anxiety model (BEIAM)	Interview anxiety, traits, interviewer judgment	(Feiler & Powell, 2015).

Table 2.2 Continued

A theoretical model of interviewee performance	*General Attributes* Mental ability, Personality, Education, training and experience, Interest, goals & values *Core Candidate Qualifications* Declarative knowledge, Procedural skills and abilities, Motivation *Supplemental Preparation* *Interviewer-Interviewee Dynamics* *Interviewee State Influences* • Interview self-efficacy • Interviewing motivation • Interview anxiety *Interviewer Information Processing Effects* *Interview Design Considerations* Level of structure, Interview medium, Pre-interview information *Demographic/Personal Characteristics* Cultural background, Attractiveness, Race & gender	(Huffcutt et al., 2011)

The constructs that dominates most of the models are meant to define what interviewers really measure. BEIAM and the theoretical model of interviewee performance however centred their constructs on interviewee's behaviours that influence performance during interview session. However, since BEIAM gives credence to only interview anxiety it will be most suitable to subsume it into the state influence of interviewee performance model that truly described the mental state that can sway interviewee. Consequently, three main constructs of interviewee states influence of the interviewee performance model (self-efficacy, motivation and anxiety) is explored to define the domain model of this study.

2.3 Identifying the Domain Model Constructs of Interviewee Mental State

Conditions of candidates facing interview situation have a great potential for influence the level to which they can present their true self during the interview session. The three human factor that can manoeuvre candidate's states worthy of note is interview specific self-efficacy, interview specific motivation, and interview anxiety (Huffcutt et al., 2011). These interplaying complexities of the constructs can define emotions which are found to be fundamental to human cognition (Janson & Marsden, 2016).

2.3.1 Interview Self-efficacy

Self-efficacy is the judgment of one's aptitude to execute a course of action required to succeed in a prospective situation (Bandura, 1997; Bandura, 1995; Wood & Bandura, 2013). The feeling of belief and trust in one's capability to face and conquer a challenge, termed self-efficacy, is one of the most widely researched areas of psychology due to its accepted significance on motivation and performance or goal attainment. Bandura proposed a self-efficacy theory that perceived self-efficacy influences what resources or behaviour an individual initiates to cope with stress and challenges, along with determining how much effort will be expended to reach one's goals and for how long those goals will be pursued (Bandura, 1997). He posited that self-efficacy is a self-sustaining trait; when a person is driven to work through their problems on their own terms, they gain positive experiences that in turn boost their self-efficacy even more.

Self-efficacy is explained in the theoretical framework of Social Cognitive Theory by Bandura (1986, 1997, cited by Meral, Colak, & Zereyak, 2012) which stated that human achievement is a function of the interactions between one's behaviours, personal factors and environmental conditions. The context of this framework is an approach to understanding human cognition, action, motivation, and emotion that assumes that we are active shapers rather than simply passive reactors to our environments (van der Bijl &

Shortridge-Baggett, 2001; Wood & Bandura, 2013). In order to build self-efficacy for a task-specific performance, conceptualizing based on the model in (Schunk, 1995) suffices. The deduction from this model is that prior to engaging in a task, there exist an element of self-efficacy that an individual possesses. This is conceptualized as function of prior experience in similar event, personality (quality defined by values and attitudes), and social support (weak or strong ties or assistance enjoyed from close associates or within social networks).

In a similar study, Schunk and Pajares (2009) identified anxiety, motivation, prior experience, skills, cognitive ability, and social issues among the factors that contribute in one way or the other to influence self-efficacy. Interview candidate's self-efficacy affects the interview performance due to the significant role it played to mediate personality and biographical variables (Tay, Ang, & Van Dyne, 2006). It further added that that the relationship between interview success and subsequent interview self-efficacy is moderated by locus of causality attributions.

2.3.2 Interview Motivation

Motivation is the desire that is emotionally triggered or activated by an external stimulus to pursue a goal (Yee & Braver, 2018). As an innate human potential power that energizes behaviour (Diefendorff & Chandler, 2011; Van Iddekinge, Aguinis, Mackey, & DeOrtentiis, 2018), motivation is capable of transforming human thought (information) into action (energy). Any cognitive behaviour is directed by motivation; therefore, human behaviours are the embodiment of motivations (Y. Wang, 2007; Yee & Braver, 2018). A number of internal, environmental, and social source influences interviewee motivation, which can manifest at many levels of the interview process (Marcus, 2009). For example, the interviewee performance can be influenced by the degree to which they are motivated to partake in the entire process and to do well.

The consistent issues by most motivation theories are centred on how human needs and desires are shaped by environmental and social factors and how the drives for these needs are influenced by subjective self-beliefs. This concept can be viewed in three different perspectives: *trait-centred, situation-centred* and *interactional views* (Weinberg, Robert & Gould, 2011). Trait-centred viewed motivated behaviour primarily from inherent characteristics point while the situation-centred contends that the level of motivation is primarily determined by perceived/experienced situation. The interactional view suggests that motivation results from the interactions of two factors namely; *intrinsic* and *extrinsic*. These concepts explain the derivation of sources either from the internal drive or from external expectations. The definition of interviewee motivation construct involves the theories and concepts that support the interactional view because employment interview is time bounded achievement oriented social task (Huffcutt et al., 2011) and focuses more to the extrinsic drive.

Among theories of motivation that have been extensively used to providing understanding upon which cognitive agent model of achievement motivation can be based are Expectancy-Value Theory (De Brabander & Martens, 2014; Pajares, 2009; Wigfield & Eccles, 2000), Self-Determination Theory (Deci & Ryan, 2012; Gnambs & Hanfstingl, 2016), Flow Theory (Deci & Ryan, 2012) and Social Cognitive Theory (Chang et al., 2013; Wood & Bandura, 2013).

2.3.3 Interview Anxiety

Interview anxiety which is the heightened tense or nervousness experienced by the interviewee prior to and during the job interview (Jeske et al., 2018; Powell et al., 2018) can be recognized on three levels of cognitive (particular thought process), somatic (physical response), or behavioural (patterns of behaviour) (Juuso, 2011). A number of reports have shown that candidates who were anxious in the job interview received significantly lower ratings of interview performance and less likely to be hired (McCarthy & Goffin, 2004; Feiler & Powell, 2015). Therefore, the capacity to comprehend and manage one's anxiety during interview should be a dire concern for any intelligent system that intends to enhance interviewee performance.

One of the related studies in this area in relation to interviewee performance is that of (McCarthy & Goffin, 2004). They developed and tested a multidimensional model of interview anxiety where significant multiple correlations between their five interview anxiety scales (communication, appearance, social, performance, and behavioural) and interview ratings were found. The research by Tross and Maurer (2008) found the negative relationship between interview anxiety and interview self-efficacy. This suggests that one consequence of interview anxiety is reduced confidence that one can perform well in an interview. Carless and Imber (2007) found that interviewer characteristics such as warmth and use of humour reduced interviewees' level of anxiety. A recent study by Feiler and Powell (2015) investigated the behavioural cues, trait judgments about interviewee anxiousness and attendants lower ratings. The findings showed the relationship between interview anxiety and performance is mediated by assertiveness and interpersonal warmth. However, speech rate, mediated the relationships between interviewee and interviewer ratings of interview anxiety.

Interviewee states influence is very influential in determining interviewee behaviour from the obtained studies and concepts reviewed so far. The summary of the constructs in interviewee state influence in respect of factors, theories and studies are in Table 2.3.

Table 2.3

Summary of Factors in Interviewee States Influence

Main construct	Related factors	Authors
Self-efficacy	Motivation, performance, anxiety, conscientiousness, agreeableness, emotional stability, openness to experience, extraversion, academic achievement, leadership experience, internal locus of causality	Schmidt & DeShon, 2010; D. H. Schunk & Pajares, 2009; Schunk, 1995; Schunk, 1991; Jeffrey B Vancouver & Kendall, 2006; Wood & Bandura, 2013
Motivation	Performance, self-efficacy, training, experience, expectancy, value, goal orientation, anxiety.	Cherian & Jacob, 2013; Day & Allen, 2004; Graham & Weiner, 1996; Schunk, 1995; Weiner, 2013, De Brabander & Martens, 2014
Anxiety	Confidence, performance, stress, cognitive recall, assertiveness, interpersonal warmth, speech rate, worry, threat, personal resources, situation demand	Hanton & Connaughton, 2002; Koivulaa, Peter, & Johan, 2002; Covassin & Pero, 2004; McCarthy & Goffin, 2004; Tross & Maurer, 2008; Feiler & Powell, 2015

2.4 Components in Interview Coaching Systems

Intelligent tutoring systems have been implemented using different platforms and processes across domains. While some are in a form of simple online training applications others are agents based with a considerable level of intelligence for inclusive teaching and learning. (Lee & Marsella, 2011; Cafaro et al., 2012; Brandao, Reis, & Rocha, 2013; Gris Sepulveda, 2013).

Virtual agents that display social skills such as displaying different attitudes are usually referred to as relational agents (Callejas et al., 2014). A number of studies have been conducted on implementation of system on social skill (verbal and non-verbal cues such as gestures, gaze, postures) adaptation or training on virtual agents (e.g., Bickmore & Gruber, 2010; Bickmore, Fernando, Ring, & Schulman, 2010; Puskar, Schlenk, Callan, Bickmore, & Sereika, 2011; Lee & Marsella, 2011; Cafaro et al., 2012).

With respect to job interview coaching, Prendinger, Mori, and Ishizuka (2005) developed an embodied agent (the Emphatic Companion) in the setting of job interviews that is able to recognize physiological data of users in real-time. The system interprets the signals as affective states and then responds to affect using an animated agent. In Kwon et al. (2013) a virtual job interview simulation to coach students of a university in preparation for their first job interviews was developed. The virtual agent, though with a minimal verbal behaviour, investigates the human anxiety state during the course of interview simulation. The physiological data of the user behaviour (skin conductance response, SCR, and pulse rate, PR) were captured. The data collected and analysed using customized analysis software for pre-processing.

Hoque (2013) design an affective framework to enhance human verbal and non-verbal skills in an interview situation. The system, known as My Automatic Conversation Helper (MACH), is a novel system using virtual agents to provide social skills and provides feedbacks on several low-level behavioural patterns such as prosody, pitch variation, pause duration, speaking rate, etc. to users. MACH framework makes provision for facial expression processing (seeing), speech recognition and prosody analysis (hearing), and speech and behaviour synthesis (responds) modules for real-time and live feedback on user's non-verbal behaviours. Anderson et al. (2013) proposed the TARDIS framework as an interview coaching system representing training interactions as a scenario-based game. The framework for TARDIS incorporated Non-verbal Behavioural Analyser (NovA) module to handle lower level social cues such as smiles, laughter, posture, gesticulation and eye contacts. However, module for the prediction of higher-level traits is not incorporated in the framework. The main modules are; the Scenario module which controls the discourse during the interview, the Social Signal modules (affective model of emotions and social attitudes, referred to as mental states), the Affective Module (model of beliefs and intentions), and the Animation module (for expressing the recruiter's affective state).

Similarly, (Callejas et al., 2014) designed an adaptive model of multimodal social behaviour for embodied conversational agents. The context of the work is the agent acting as a virtual recruiter interacting with users during session of job interview training. The agent is able to adapt its social behaviours based on the level of anxiety of the trainee. The architecture has components such as the *Dialog Manager* that selects the appropriate system response and the social attitudes of the virtual recruiter's to express base on user's anxiety level. The data for the analysis is obtained through user's audio-visual or physiological signals. Other components of the virtual agent are the *Agent Mind* which stores the social attitude to be accessed by the *Natural Language Generator (NLG)* and the *Behaviour Planner*. There is also, the *Behaviour Realizer* and the *Text-To-Speech (TTS) engine* that display the animation of the agent.

The University Virtual Interview Coach (UVIA) was introduced by Universiti Utara Malaysia (UUM) to provide training supports to students having problems with an interview (Subri, 2014). The system using virtual agent trains the user on basic interview skills, then test the user's confidence and skills by simulating interview where several interview questions are asked and the response recorded. A computational framework for automatically quantifying verbal and nonverbal behaviours in the context of job interviews was developed in (Naim et al., 2018). The framework consists of modules for quantifying influences of low-level features on the interview, predicting several high-level personality traits, and providing feedback on the overall interview performance.

The coaching system architectures and their basic supported components are summarised in Table 2.4 below.

Table 2.4

Supported Components of Coaching Systems

Components	**Interview Coaching Systems/Frameworks**						
	Prendinger, Mori, and Ishizuka (2005)	**Kwon et al. (2013)**	**MACH Hoque (2013)**	**TARDIS Anderson et al. (2013)**	**UVIA Subri (2014)**	**Callejas et al. (2014)**	**Naim et al. (2018)**
Feedback			X	x	x	x	x
Physiological data using Sensor Module	x	x				x	
Audio visual inputs			X	x	x	x	x
User Interface Animation and Text to Speech Engine	x				x	x	x
Analytical Engine	x	x	X	x	x	x	x
Natural Language Processors						x	
Nonverbal behaviour analyser			X	x		x	x
Mental state analyser for social signal				x			
Affective Module (model of beliefs and intentions	x	x	X	x		x	x
Animation module	x	x	X	x	x	x	x

This section provided some of the efforts in technology to providing instructions or coaching in the interview domain. While considerable achievements have been recorded, attentions were not focused on intelligence based on human behaviour adaptation. The architectures focused on coaching and support on verbal and non-verbal observable behaviours of the systems they implemented. Perhaps only the TARDIS framework specifically included the mental state of employee module designed for recording and analysing the social and psychological signals to capture the interviewee's conscious and unconscious behaviours. However, the context is based on the capturing and processing of nonverbal cues such as smiles, head nods and body movement using a combination of remote sensing devices and software algorithms. Incorporating the mental state module with an agent model contrived from interviewee state influence (i.e., the constructs of self-efficacy, motivation and anxiety status) will further enrich the framework as an intelligent engine hence improved reasoning capacity.

2.5 Computational Cognitive Model

Computational cognitive science is concerned with bridging the fields of artificial intelligence and psychology through research based on computer modelling of human cognitive processes (Boden, 2008; Vancouver & Weinhardt, 2012). The goal of cognitive modelling is to enhance the understanding of internal mechanisms of thought so as to see the working of thinking (Friedman, Forbus, & Sherin, 2018). The significance of the study of cognition is connected to its relationships to deep philosophical questions about the nature of mind and consciousness (Friedman et al., 2018; Nichols, 2006). Relatively research in cognitive modelling explores the essence of cognition and various cognitive functionalities through developing detailed, process-based understanding by specifying corresponding computational models of representations, mechanisms, and processes. Models can be developed in practically all strata of human and natural systems. However, models in cognitive science can be broadly categorized into verbal-conceptual, mathematical, and computational models (Simon Farrell & Lewandowsky, 2015; Lewandowsky & Oberauer, 2018). While computational models use algorithmic descriptions to present process details, mathematical models use equations to presents relationship between variables whereas verbal-conceptual models use informal natural languages to describe entities, relations and processes (Sun, 2008). The basic objective of a model is to facilitate understanding by eliminating unnecessary details, to aid decision through simulation and to explain, control and predicts based on observed events (Farrell & Lewandowsky, 2010). The main idea centres on simulating a runnable computational model whose attributes relates to cognitive functions in a domain (Sun, 2008).

The working computational model guarantees that a theory is unambiguous, internally consistent , accounts for the claimed phenomena, and specified sufficiently(Adner, Pólos, Ryall, & Sorenson, 2009; Farrell & Lewandowsky, 2010; Harrison, Lin, Carroll, & Carley, 2007; Lewandowsky & Oberauer, 2018). The precise and unambiguity of the computational model allows for its easy disconfirmation since working models are not necessarily valid. That is why model evaluation is considered paramount in any model development process (Vancouver & Weinhardt, 2012). Hence a thorough development stage of the model in this study considers evaluation both internally and externally with a human experiment to give credence clearly to the logic of the fundamental theories applied.

2.5.1 Modelling Techniques

Different research in modelling has adopted a number of approaches to modelling. Set of assumptions about the system being modelled informed the selection of a particular modelling technique. Functional composition of many models allows for incorporation of several techniques to achieve the level of abstraction expected in the system (UK Government Office for Science, 2018). Among the techniques that have been used in related research are

Differential equation: Used for a dynamic model where output changes over time. Dynamic models are based on concepts such as feedback, equilibrium, non-linearity and stiffness. Differential equations are also essentially deterministic in nature used to describe physical or economic systems and making absolute assertions about behaviours. However, many aspects of the physical world, such as human behaviour, are non-deterministic in nature hence not useful to try to model them in a deterministic way. Differential equations can also underpin continuous (time change) models that are used to describe physical systems and forecast economic changes (Hermann & Saravi, 2014; Sobie, 2011; Zill, 2012). Additionally it can extend stochastic models (statistical or probabilistic) (Guttorp & Minin, 1995).

First Order logic: The principal benefit of a logic approach is that it allows inference from the model through mathematical proof, therefore the correctness of models can be reasoned (Bartocci & Lió, 2016; Donzé et al., 2012). The downside is the complexity of this sort inference. Logic-based models are often applied in modelling computer and communication systems.

Automata and algebraic models: best suited for simple representations of multiple processes occurring at the same time. In addition to modeling concepts in computing especially in distributed computer systems, they have more recently been applied to subjects from molecular biology to traffic congestion (Bartocci & Lió, 2016). Process algebra models may be stochastic, discrete or continuous. Due to strong correspondences between algebraic and logic representations, the two approaches share similar advantages and disadvantages

System dynamics: System dynamics (SD) modelling is a computer simulation approach to revealing how behaviours change over time in order to find effective policies to guide organisations. The models concentrate on how different elements of an organization interact to make an aggregate view (Block, 2018; Sweeney & Sterman, 2007). The focus is on understanding the structural source of general patterns of behaviours and not to obtain forecasts of precise behaviour over time (UK Government Office for Science, 2018).

Agent Based Models: this is best suited for modelling systems of numerous interacting agents where the behaviour of the whole system cannot be derived from the behaviour of the individuals (Bartocci & Lió, 2016). Typical examples include non-deterministic human behaviours, social insects, extremely large telecommunications networks (including the internet), transportation networks, and stock markets. The technique usually contains sets of autonomous agents each representing individuals or groups with similar characteristics. Analysis typically combines verification using both logics and large-scale simulations, enabling modellers to explore emergent properties or predict when tipping points will be reached. Such explorations are often very computationally intensive (Macal & North, 2009)

Other approaches that have been applied in many domains are Rule-based, Lattice-based model, state chart model, hybrid systems, Boolean/quantitative networks, Continuous Time Markov Chains, and Petri Nets (Bartocci & Lió, 2016). Modeling techniques are often combined to provide for a strong domain-specific technique such as in a dynamic population model that uses differential equations. Safe for the resultant complexity of the analysis or poor automated supporting tools, a model can combine several techniques with different states or segments approached differently. Example is in a dynamic model with discrete states and transitions between them where each discrete state is modeled with a set of differential equations that describe the continuous behavior that applies during that state (Block, 2018).

2.6 Agent-Based Modelling (ABM)

Agent-based-model at the simplest level consists of a system of agents and the relationships between them which can be described by a set of equations (Bosse, Duell, Memon, Treur, & Van der Wal, 2014). The system is capable of exhibiting complex behaviour patterns in terms of changes and adaptation in response to environmental challenges or to neighbouring agent behaviours (for example, competition or collaboration) (Conte & Paolucci, 2014; Simon Farrell & Lewandowsky, 2015). ABM has been introduced as a tool for generating and improving theories, testing hypotheses, and facilitating the investigation of social processes from the intra-individual through to the societal level (Eberlen, Scholz, & Gagliolo, 2017)..An independent component's behaviour can range from simple, reactive if-then decision rules, to general behavioural models, such as the BDI (Belief-Desire-Intent) framework, to complex models based on artificial intelligence (AI) (Bartocci & Lió, 2016; Hoogendoorn, Memon, Treur, & Umair, 2010; Poole & Mackworth, 2017).

ABM has its main roots in modelling human social and organizational behaviour and individual decision-making (Bonabeau, 2002). The applications can be found in; modelling agent behaviour in the stock market (LeBaron, 2002), planning electrical grids in developing countries (Alfaro & Miller, 2011), model of supply chains with dynamic structures supply chains (Li & Chan, 2013), for resource allocation during relief distribution (Das & Hanaoka, 2014), predicting the spread of epidemics (Gilbert, Meyers, Galvani, & Townsend, 2014), and modeling for water resources planning and management (Berglund, 2015). In application specific area that relate to cognitive science (understanding how human mind works) ABM has recently been applied to analyse emotion contagion in groups (Bosse et al., 2014), measuring the impact of beliefs and communication on attitude dynamics (Brousmiche, Fournier, Kant, Prenot-Guinard, & Sabouret, 2014) , understanding abrupt transformation of phobic behaviour after a post-retrieval amnesia (Soeter & Kindt, 2015), modelling human support agent for managers during stress (Noraziah, Azizi, & Haneed, 2016), Formal analysis of temporal dynamics in anxiety states and traits for virtual patients (Azizi et al., 2016), as an approach for simulating interactions between occupants and building systems (Jia et al., 2017), and modeling of cognitive learning of dynamic activity-travel patterns for a better understanding of the individual's spatial cognition and mental representation of urban networks development over time (Cenani, Arentze, & Timmermans, 2013)

2.6.1 Related Models in Personality and Social Psychology

The fundamental role played by human mind in human performance is the main reason why it is the centre of attention of various studies especially in cognitive psychology (Friedman et al., 2018). In line with the purpose of this study, a review of the previous study in computational model relating to personality and social psychology is relevant to shape the focus of the research. Table 2.5 provides a summary of related research in computational models in psychology.

Table 2.5

Review of Cognitive Models in Personality

Author	**Model**	**Description**	**Base Theories /Models**
Nitta, Tanaka, Nishida and Inayoshi (1999)	Model of the human mind	Implementing non-intellectual functions of the human mind on computer systems. The model defines how anxiety can be avoided or decreased using a defensive mechanism at unfavourable events.	Psychoanalytic theory of personality
Romano, Ka, and Wong (2004)	Personality model of a social character	Model personality based on social cognitive factors (social knowledge, personal goals, personal standards, expectations about the world, reflections upon oneself, and affective experiences).	Social Cognitive Theory
Taihua, Yuhui, Peng and Guoxiang (2007)	The framework of a learning companion agent with personality and emotions.	A learning companion agent uses the emotional state, mood, and personality to create behaviours.	Five-Factor Model of Personality (FFM)
Liu (2008)	A personality model of virtual character	Integrates stimuli, perception, personality, motivation, emotion, and behaviour	Five-Factor Model of Personality (FFM)
Karimi and Kangavari (2012)	A Computational Model of Personality (PIACT)	An extension of ACT-R cognitive architecture, to consider the effect of personality factors. Trait anxiety is the personality component considered for the model.	Five-Factor Model of Personality (FFM)
Ahrndt, Fähndrich, Lützenberger and Albayrak (2015)	Modelling of Personality in Agents: From Psychology to Logical Formalisation and Implementation	Motivate the impact of personality on essential elements of the behaviour of agents (e.g. decision-making processes, emotions, moods, or coping strategies)	BDI Architecture
Muszyński and Wang (2017)	Happiness Pursuit: Personality Learning in a Society of Agents	Modelling personality is a challenging problem with applications spanning computer games, virtual assistants, online shopping and education.	Deep Q-Network (DQN) model

In summary, there are many works on personality modelling but the emphasis was on a specific view according to the researchers' standpoint. Though the models analyse personality with a focus on personality theory and social cognitive factors, none has been able to formally combine the three basic constructs of self-efficacy, motivation and anxiety in the context of personality driving force at a challenging event. It is noted that achieving a complete model of personality within the purview of this study needs recognition of more aspects of personality and consideration of dynamism, formalization and testing in a simulation environment as well.

2.6.2 Computational Models Related to Domains in Cognitive Sciences

There are numerous none computational models or theories defining human behaviour either as motivational, performance, efficacy, experience or combinations of the variables (e.g., Fried & Slowik, 2004; Ackerman, 2010). These theories only define the dynamism of the constructs they represent but not really tested to identify their computational inclination. According to Vancouver et al., (2010) dynamic relationships predicted without the aid of formal computational models are really disposed to errors.

Several types of research on formal modelling in cognitive related domains abound as summarized in Table 2.6.

Table 2.6

Dynamic Models in Related Domains

S/N	Author(s)	Description	Technique
1	McQuiggan et al. (2008)	Computational modelling of self-efficacy using physiological biofeedback signals	System dynamic process
2	Wang (2008)	A formal model of relationships between motivation, attitude, a behaviour termed Motivation/Attitude-Driven Behaviour (MADB)	ABM
3	Topolinski (2011)	A process model of intuition	Process based
4	Bosse, Memon, et al. (2011)	A Recursive BDI Agent Model for Theory of Mind and Its Applications	First Order Logic
5	Vancouver and Weinhardt (2012)	A formal model of job attitude and stress	ABM
6	Soleimani and Kobti (2012)	A Mood Driven Computational Model for Gross Emotion Regulation Process Paradigm	Differential Equation
7	Pontier, Van Gelder, and De Vries (2013)	A computational model of affective moral decision making that predicts human criminal choices	ABM
8	Steephen (2013)	Hed: A computational model of effective adaptation and emotion dynamics	Differential Equation
9	Reisenzein et al.(2013)	Computational Modeling of Emotion	ABM
10	Shell and Chiriacescu (2014)	A computational model of self-efficacy	ABM
11	Callejas et al. (2014)	A computational model of social attitude for virtual agents which acts as a virtual recruiter	System dynamic process
12	Bosse et al., (2014)	Agent-Based Modeling of Emotion Contagion in Groups	Differential Equation
13	Abro et al.(2015)	Modelling the effect of regulation of negative emotions on mood	Differential Equation
14	(Azizi Ab Aziz et al., 2016)	Formal analysis of temporal dynamics in anxiety states and traits for virtual patients	Differential Equation
15	Vancouver & Purl (2017)	A computational model of the multiple processes presumed to create the positive, negative, and null effects for self-efficacy	ABM

Combination of the dynamic characteristics of most of the models with the specificity of the models in personality earlier described provides a platform for build the model that would suit the purpose of this study.

2.7 Evaluation Methods of Formal Model

Model evaluation which simply implies the sets of action taken to ensure that a model is properly developed is a vital step in computational modelling development process. It is the range of activities needed to be done to ascertain that the modelling processes are robust and the attendant outcome is sufficiently accurate and credible (Antoniadou, Barthorpe, & Worden, 2014). Therefore, model credibility and usability are related topics that are concerned with evaluation (Pace, 2004). Verification and Validation (V&V) are two evaluation procedures adopted at various stages of ascertaining model's fidelity (Sargent, 2015). These procedures are used to evaluate evidence to determine the capabilities of simulation, its limitations and performance in relation to the real-world situation or a given standard (Sarget, 2013).

2.7.1 Model Verification

This process seeks to answer whether the model is built rightly. For example, to ensure that the computer program of the computerized model and its implementation are correct (Sargent, 2013). Mathematical analysis and logical verification are among two well-known verification techniques for an agent-based computational modelling approach.

Mathematical analysis methods have been applied such as stability analysis (mathematical proof for equilibrium point determination) (Bosse et al., 2014; Bosse, Jonker, Van Der Meij, Sharpanskykh, & Treur, 2009), and sensitivity analysis (the varying of the model parameters to observe the behaviour of the simulation) (David, 2013; Vancouver & Weinhardt, 2012). Several techniques are available also for logical analysis or automatic verifications of models. The formal verification of a program consists of proving that its execution satisfies a given specification of the possible temporal behaviours it should display (Antoniadou et al., 2014). In order to study the dynamics of a simulation model, certain dynamics statement (i.e., temporal logical expressions), which either expected or not expected to hold, are automatically verified against simulation results (e.g. traces or patterns).

Some logic-based languages that are used to specify temporal behavioural properties of a simulated model are; 1) Linear Temporal Logic (LTL) (operates on a single path of the model execution, and a temporal property can be formulated only for one possible trajectory of the system) (Chatterjee, Chmelik, Gupta, & Kanodia, 2015), 2) Computational Tree Logic (CTL) (have in their syntax special quantifiers that enable the specification of properties over all the possible trajectories or branches in time) (Clarke, Emerson, & Sistla, 1986), and 3) Signal Temporal Logic (STL) (extends LTL with the continuous time semantics and with predicates over real variables) (Donzé et al., 2012). Other well-established formal verification techniques are model checking, (Donzé et al., 2012), runtime verification (Donze, 2010), and static analysis (González, 2012).

Temporal Trace Language (TTL) has been used extensively for automatic verification in cognitive models. TTL supports formal analysis of dynamic properties of a system, covering both qualitative and quantitative aspects. Dynamic properties are temporal statements that can be formulated with respect to traces based on the state of the biological entity being analysed. TTL is built on atoms trajectories (traces) of states over time (Hoogendoorn, Jaffry, & Van Maanen, 2011). This technique has been implemented in (Bouarfa, Blom, & Curran, 2016; Guttorp & Minin, 1995; Hoogendoorn, Jaffry, Van Maanen, & Treur, 2014)

2.7.2 Model Validation

Validation provides answers to the question of whether the right model is built (Sargent, 2013). Technically, it is a process of formulating and substantiating explicit claims about the applicability and accuracy of computational results, with reference to the intended purposes of the model as well as to the natural system it represents (Antoniadou et al., 2014; Hicks, Uchida, Seth, Rajagopal, & Delp, 2015; Sargent, 2015). This ensures that the developed model is working in conformity to the base theories and expert opinions as identified from the literature. Several validation approaches have been adopted to evaluate computational models in social systems. Bharathy and Silverman (2010) itemizes these approaches as 1) conceptual or theoretical validation (where experts determine the accuracy of the constructed model in characterizing the real world) (Sargent, 2013), 2) cross-model validation (where validity is determined by comparing different models), 3) external validation (conducting experiments against real world, e.g. human experiment), 4) data validation (comparison of the model data with the real world data) (Hoogendoorn et al., 2011, 2014), and 5) internal validation (validity of the proposed model based on simulation results (Hoogendoorn et al., 2014)

2.8 Model Integration

Modeling complex systems involves an inevitable designs of separate constituent models representing basic entities of the system which can operate independently yet achieve the overall objective of the system in synergy (Belete, Voinov, & Laniak, 2017; Chechik, Nejati, & Sabetzadeh, 2012). However, as to develop all-inclusive models is difficult, therefore, individual models that represent specific domains must be integrated to provide unified understanding about the properties that the system must satisfy (Gregersen, Gijsbers, & Westen, 2007). Thus, the fundamental issue of how to integrate different constituents of the model into a single, sophisticated, integrated model that can be used to represent and operationalize the system being observed must be solved (Chechik et al., 2012).

Since, individual models are technically designed as standalone components that serves unique goals and purposes, the challenge lies in resolving the interoperability that different levels of each of the models provided (Belete et al., 2017). These levels are technical which ensures models communicate with each other through automatic data exchange, and joint execution (Knapen et al., 2013), and semantic level which ensures that models understand each other. The interoperability that ensue after the semantic mediation allows data produced by one model to serve as input for a receiving model (Belete et al., 2017).

2.8.1 Model Integration Process

In order to enhance the explicit declaration of the complex relationships between the constituent models, an integration process in which the relationships are encoded as firstclass artifacts is proposed in (Chechik et al., 2012). The process begins with specifying the relationships between models (i.e., overlap, interact, or cross-cut), and then selecting the appropriate integration operator based on the type of relationship identified (e.g., merge, compose or weave).

According to Chechik et al. (2012), a kind of association must be identified between models to define the relationship and the operator to use in binding them. These relationships may include interact, overlap, and cross-cut. Models overlap when same concept or information on closely related concepts appear in multiple models while model interaction involves the communication processes of different models during execution or simulation. Another concept, cross-cutting is the overreaching behaviour of a model to alter the behaviour of another in response to safety, security and performance concerns. The choice of integration operator or activities therefore is dependent on the relationship which holds between the models. They are identified relatively as merge, composition or weaving according to the relationship type as shown in Table 2.7.

Table 2.7

Model Integration Relationship versus the Operators

Relationship	**Integration Operator**
Overlap	Merge
Interact	Compose
Cross-cut	Weave

Merge is used to integrate and present a global view of a set of overlapping models wherein different angles of the same functionalities are captured. Composition on the other hand is used to integrate a set of autonomous but interacting constituent models that run sequentially or in parallel. Lastly, weaving operator is used in aspect-oriented development to integrate cross-cutting concerns into the main system (Belete et al., 2017).

The process of model integration follows sequence and iteration procedures similar to that of model development (Holzworth et al., 2014; Holzworth, Huth, & de Voil, 2011), with realization of a minor portion of the integration in the beginning and then more components integrated during the iteration (Belete et al., 2017). The phases involved in model development includes requirements analysis, design, implementation, and testing (David et al., 2013; Whelan et al., 2014). Belete et al. (2017) itemize phases of integration as pre-integration assessment, preparation of models for integration, orchestration of participating models during simulation, data interoperability, and testing.

2.8.2 Approaches for Technical Integration of Models

Technical integration can be harmonized by organising models at the simulation by enabling and handling relationships between components (Madni & Sievers, 2014). This task of harmonization involves identifying components to be included; creating linkages and general workflow to be implemented; and handling execution of the workflow. Additionally, the nature of the data exchange operation in an integrated model may either be feed forward (sequential) where execution of a component is completed and produces data for subsequent consumption; or feedback (iterative) where components require the exchange of intermediate data values at certain time steps (Belete et al., 2017; Madni & Sievers, 2014).

Literature on model integration has specified different technical interoperability of models methods that can be used. This can be categorized into component-based, web service-based or System Oriented Approach (SOA), a hybrid of component, web service-based, and tailor-made (custom-made) techniques Belete et al. (2017). Table 2.8 presents the comparison of these methods done in Belete et al. (2017).

Table 2.8

Technical Integration Methods Commonly Used by Integration Frameworks.

	Component-based	**SOA-based**	**Hybrid of component-based and SOA**	**Custom-made**
Primary characteristics	Reusability of components and system level functionalities. Involves component production and integration or utilization	Loosely coupled systems; distributed services. Enables building distributed applications through connecting autonomous services regardless of heterogeneity	Models as components and as SOA.	An ad hoc collection of methods/techniques is used.
Advantages	Plug and play; separation of concern; minimizes context switching time of components.	Plug & play; location independence; platform independence; scalable.	Enables linkage to different frameworks; manage heterogeneity; reuse existing frameworks.	Developers can use ad hoc techniques for orchestration
Disadvantages	Developing reusable orchestration engine is challenging.	May require heavy data exchange, and high availability.	Requires parsing data between components and web services.	May not support new version of models; lack of extensibility.
Examples, Reference	ESMF (DeLuca, 2014); CSDMS (Peckham, Hutton, & Norris, 2013)	GEO (Nativi, Mazzetti, & Geller, 2013); AWARE (Granell, Díaz, & Gould, 2010), eHabitat (Dubois, Schulz, Skøien, Bastin, & Peedell, 2013)	(Castronova, Goodall, & Elag, 2013), (Castronova et al., 2013)	APSIM, (D.P Holzworth et al., 2014);CMP (Moore, Holzworth, Herrmann, Huth, & Robertson, 2007).

It is observed that the overall describtion of the the processes and frameworks in literature differ extensively in aspects of the integration process and the level of details of the presentation.

2.9 General Review of Related Work

The theoretical model of interviewee performance has elaborately described several constructs that combine to define the performance of the interviewee from the perspective of the interviewee state influence, candidate's qualification, the interviewer-interviewee dynamics, and other salient issues such as demographic characteristics (Huffcutt et al., 2011). The central point of the model is the candidates' dynamic behaviour that affect their performance during interview. Although the core concept has been established from three main concepts of self-efficacy, motivation and anxiety, this concept is purely conceptual in nature. For example, McQuiggan et al. (2008) proffer a computational modeling of self-efficacy based on a data-driven framework. The study details the design and evaluation of an empirical approach to computational self-efficacy models. Though the model proves the relationship of self-efficacy to motivation and affects, the interconnected interplaying factors were not highlighted. The approach was top-down where model is synthesized and trained from the obtained data.

In similar vein, Wang, (2011) described the perceptual processes of emotions, motivations, and attitudes which can serve as a base for formally modelling and explaining the complicated psychological and mental processes that interplays with the constructs. The relationships and interactions between motivation and attitude were established and integrated. However, the mathematical model was not domain tailored and not formally simulated and evaluated. Moreover, the cyclic causal relationships of states were not established in the two models above that will allow the simulation of the temporal dynamics in relation to any human behavioural intricacies.

Mollee and van der Wal (2013) model self-efficacy as a subjective confidence or trust that behaviour will achieve an intended outcome. The model shows self-efficacy along with outcome expectancy providing motivation for the enhancement of the intention to perform certain behaviour which is in tune with the integration of the two agent models of self-efficacy and motivation in this study. Bica, Verdin, and Vicari (2006) predicated the use of student behavioural data (persistence, effort) during a tutorial to estimate self-efficacy for agent intervention. Among other studies in this direction which focused on modeling self-efficacy without intent to integrate with other cognitive constructs are Shell and Chiriacescu (2014), and Vancouver and Purl (2017),

A number of computational models on emotions has been studied that can be related to the concept of anxiety as used in this study. The relationship could be hinged on research evidences that emotions are functional (Oatley & Johnson-Laird, 1987) in nature and capable of providing information about a human being in mutual interaction with his or her environment (Schwarz & Clore, 1983). Emotions therefore have a strong impact on the way we interact with the social world (Gross, 2015) hence the connection with mental attributes this study intends to model. The study on the this model which can be related to anxiety can be found in Soleimani and Kobti (2012) based on Gross theor, vein, Pontier, Van Gelder, and De Vries (2013) based on the relationship between personality, ratio, affect and criminal behaviour and Steephen (2013) which uses a dynamical systems approach, employing first order differential equations, to model affective adaptation. In a much related fashion to the model of anxiety proposed in this study is that in (Abro et al., 2015) which an integrated model of emotion that describes how the emotion generation and regulation mechanisms influence the mood dynamics. Though the dynamics explored in all of these models are likened to anxiety construct, they are however not domain specific, and not evaluated.

Callejas et al. (2014) presented a computational model of social attitude for virtual agents in which the agent acts as a virtual recruiter and interacts with a user during job interview training. Though the study is specific on the domain of job interview to determine the anxiety so as to determine the attitude of the recruiter and the result is evaluated with human experiment, the work did not fashion the model of anxiety from the cognitive behavioural phenomenon. However, the study by Azizi et al., (2016) was an effort to formally analyse anxiety states and traits for virtual patients. The model was built based on the theory of generalized anxiety disorder with particular sentiment towards anxiety on a long term as an inroad to depression. The study conceptualized worry from short-term response to the event and coping strategy without the inclusion of threat as a building mechanics of affective states. However, an anxiety model that is geared towards understanding the mental states of interviewee requires the cognitive (defined by self-efficacy) and motivational factors to be reflected (Katalin Piniel & Csizér, 2013).

The techniques and methods applied in these models are generally related to the one adopted in this study. However, none of the models so far has been able to extensively harmonize the three constructs of interest (self-efficacy, motivation and anxiety) in a unified model addressing the mental state in task-specific activity. The present work differed from these studies in that its focus is on presenting a computational model of each of the constructs of self-efficacy, motivation and anxiety as cognitive phenomenon that interact to define the mental states in an interview domain. The interlinking factors are identified to serve the purpose of integration of the models into a unified mental state model amenable to the temporal dynamics of interviewee behaviour during interview sessions. The simulation is showing how the model predicts the responses to different kinds of cognitive, emotional, and motivational nuances and finally linking these observations to existing literatures. The formalized models are mathematically verified, scrutinized with automatic trace analysis and studied using human experiment to validate the accuracy. This approach is significance as emphasized by (Bosse et al., 2014; Treur, 2016c) to show pertinence in adequately describing the phenomenon the model is set measure and its applicability as a component in human-aware AI system which is the final goal of this type of research.

2.10 Summary of the Chapter

This chapter has been able to review broadly literature relating to the domain of study. The study is reviewed from three perspectives which are interview domain, technology application and cognitive modelling domain. The interview section defines the relevant concepts and the measuring constructs in employment interviews. Secondly, models and theories in employment interview related to the study are discussed. The theories discussed are a signal theory in employment interviews, the model of faking likelihood in employment interviews, the theory of self-presentation in personnel selection settings, behavioural expression of interview anxiety model (BEIAM), and theoretical model of interviewee performance. Interviewee states influence is a construct of three main factors (self-efficacy, motivation and anxiety), identified from the theoretical model of interviewee performance that can be modelled to define interviewee behaviour. Sudies on the frameworks for intelligent systems relating to coaching was reviewed and was found that little attention has been given to the module for interviewee mental state. However, the provision made in TARDIS framework for the mental state was based on measurable pysiological cues. The angle of the human psychological components from the combination of the trio of self-efficacy, motivation and anxiety constructs have not been achieved.

The last segment described computational cognitive modelling with details in computational cognitive modeling, and model evaluation techniques. Major studies in this section describe the concepts in agent-based modelling, modeling techniques, summary of studies on computational modelling in cognitive science related to the domains and model evaluation techniques. The next chapter discusses the study methodology within the spectrum of the Design Science Research Process (DSRP) with the Agent-Based Modeling approach highlighted in this chapter infused into the design component, hence setting the structure for the remaining part of the study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research framework and also the analysis and discussion of the various phases within the framework. The study adopts the Design Science Research Process (DSRP) (Peffers et al., 2007) framework and agent-based modelling approach as a guideline to conduct this study. First, the overall research framework of this study is explained in Section 3.2. Later, the detailed explanations for each phase are covered in Section 3.3 till Section 3.9. Finally, Section 3.10 concludes this chapter.

3.2 Research Framework

The Design Science Research Process (DSRP) framework was chosen as a blueprint to conduct this study. Primarily, the DRSP involves the design of models and analysing the performance of the system for improvement in the area of Information System. DSRP is driven by the need to advance the environment by the introduction of new and innovative products with a clear definition of the processes for building them (Baskerville et al., 2018; Deng & Ji, 2018; Peffers et al., 2007). The six stages of DRSP that guide this study are problem identification and motivation, objective for the solution, design and development, demonstration, evaluation, and communication (Kuechler & Vaishnavi, 2008; Schorr & Hvam, 2018). The framework as its used to tackle the various segment of the research that handles the study objectives is presented in Figure 3.1.

In addition, this framework is integrated with the agent-based modelling (ABM) approach for conceptualizing, designing and formalizing the component agent models and the integrated cognitive agent model. The ABM consists of describing a system from the perspective of its constituent primitive computational modelling units (Block, 2018; Bonabeau, 2002; Simon Farrell & Lewandowsky, 2015). Differential equation approach is one of the modelling techniques used in ABM (Hermann & Saravi, 2014). The overall process of this framework is summarized in Figure 3.1

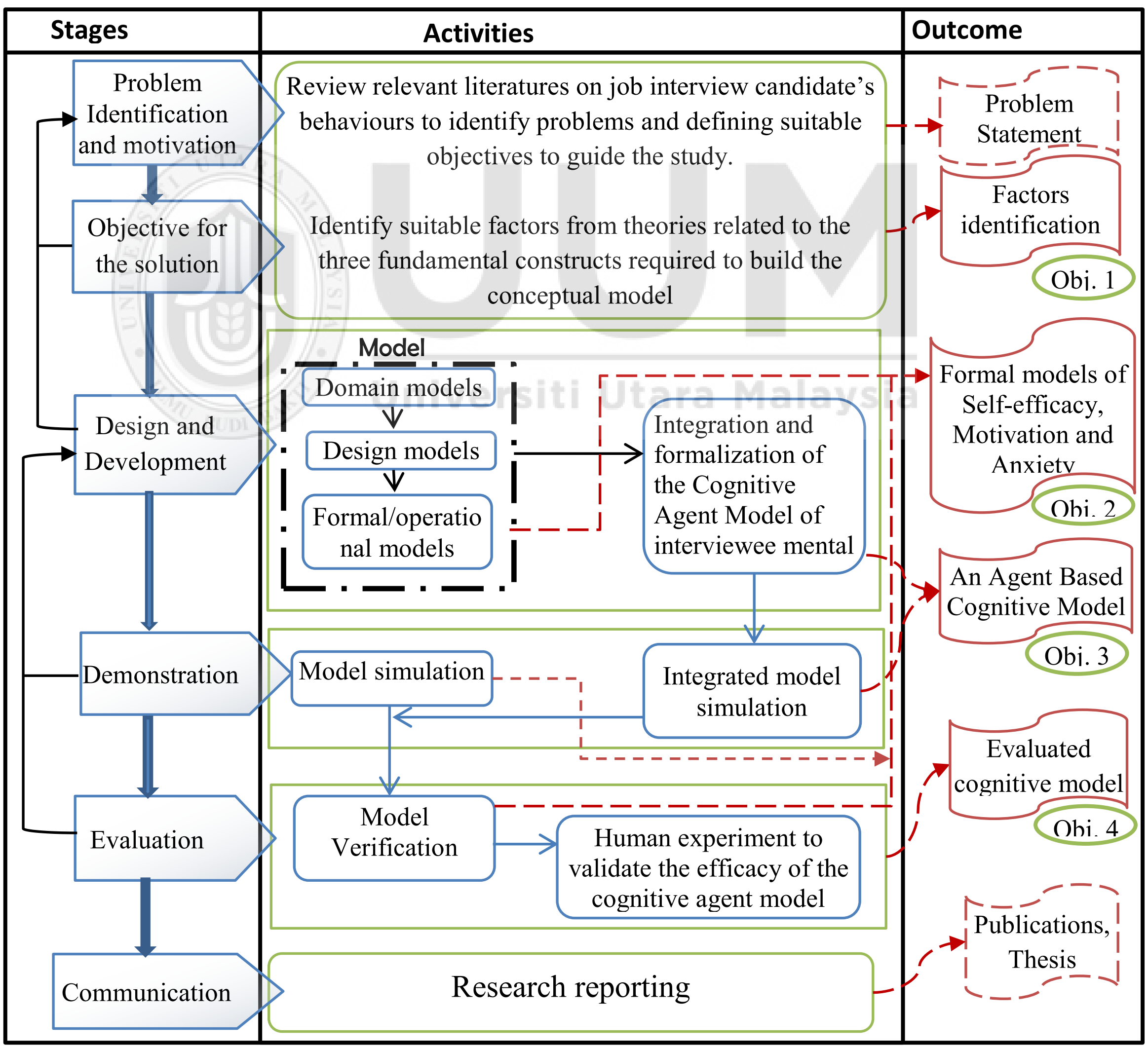

Figure 3.1. DSRP Framework for the Study (Peffers et al., 2007)

Based on Figure 3.1, each of the six components of the framework is allocated to one phase of this study. The activities that are associated to complete each stage are defined in relation to the expected output. The outputs are measured to indicate that related objectives were achieved.

3.3 Problem Identification and Motivation

The Design Science Research is grounded on existing concepts derived from the domain field. There are different sources upon which inspiration for creative design activity can be drawn which include rich opportunities/problems from the application environment, existing artefacts, analogies/metaphors, models or theories (Hevner & Chatterjee, 2010). Since the foundation of the research is defined at this stage, an extensive literature review was conducted to obtain adequate problem statement and research objectives. There are three basic categorization of literatures reviewed for the study. These are; (1) concepts and theories in job interview constructs, (2) intelligent interviewing coaching systems, and (3) cognitive agent modelling paradigms. The outcomes from this process are sets of research questions, objectives and the motivation of this study.

3.4 Objective for the Solution

After an extensive review of relevant research works which define related problem and motivation, this section provides clear objectives that guide the study. Objectives were stated with clear directions to drive the research process. The broad objective of this study is to develop a cognitive agent model of interviewee mental state with specifics to achieve the followings;

(i) analyse the inter-related factors from domain theories in self-efficacy, motivation, and anxiety during interview sessions.

(ii) develop formal cognitive agent models for the interviewee mental state constructs of self-efficacy, motivation, and anxiety.

(iii) integrate the formal cognitive agent models into a unified cognitive agent model that represents an interviewee mental state.

(iv) evaluate the designed cognitive agent model within simulated job interview domain.

3.5 Design and Development

This stage takes care of model development from the domain, the design, to the operational phases of the three fundamental constructs (self-efficacy, motivation and anxiety) that define the mental state of an interviewee. These three concepts are independent in nature and can be integrated for a monolithic model. The integration of these models into a single formal cognitive agent model for the interviewee mental state is achieved at this stage..

3.5.1 Modelling Process

A conceptual model represents ideas about the working of a system or the relationship that exist between variables in a non-formal natural language. Normally, it involves boxes or nodes (state variables) and arrows (material flows or causal effects). After all interplays between nodes are identified, it could further be combined to design a formal model consisting of dynamic (i.e., varying with time) equations of the phenomena. Later, these interplays are translated into a set of dynamic mathematical equations to be simulated on numerical programming platform for patterns and traces generation (Vancouver & Weinhardt, 2012).

Also, this model contains logical and causal relationships that occur in the systems. In order to develop a valid simulation model, an iterative process is involved to ensure the model validation steps are followed (Sarget, 2013). The flow diagram in Figure 3.2 shows the steps of model constructions from design to evaluation stages.

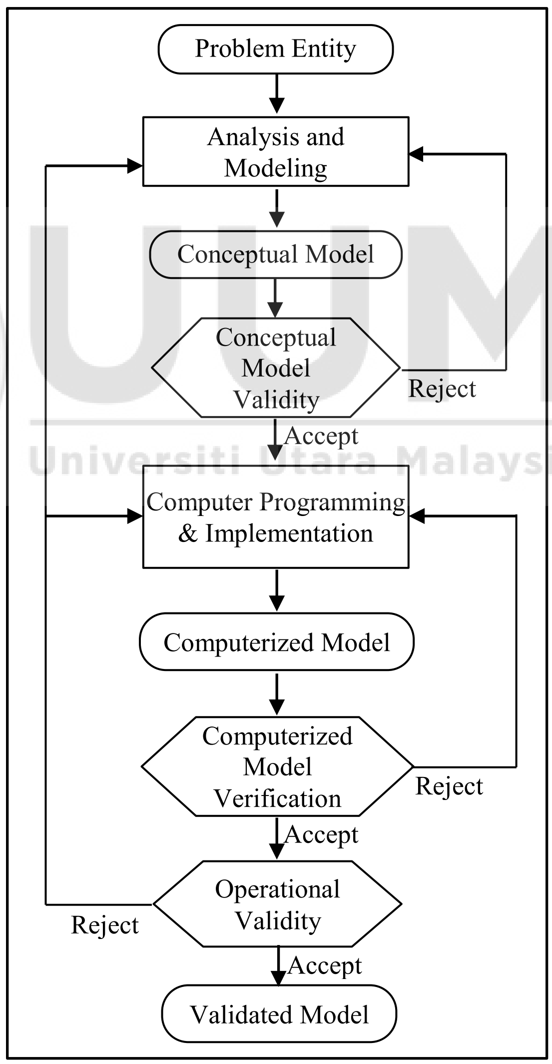

Figure 3.2. The model development iterative process (Sarget, 2013)

There are three steps involved in the construction of the models, namely, domain, design and operational models.

3.5.2 Domain Model

This model provides the conceptual representation of basic constructs and factors as identified from psychology theories, computational cognitive researches and experts' opinion identified from selected literature. Variables identified as factors that affect interviewee performance are abstracted and visualized into the domain model. The central constructs that define the state influence of an interviewee are self-efficacy, motivation and anxiety as has been discussed in Section 2.3. Figure 3.3 shows the schema involved to design a domain model.

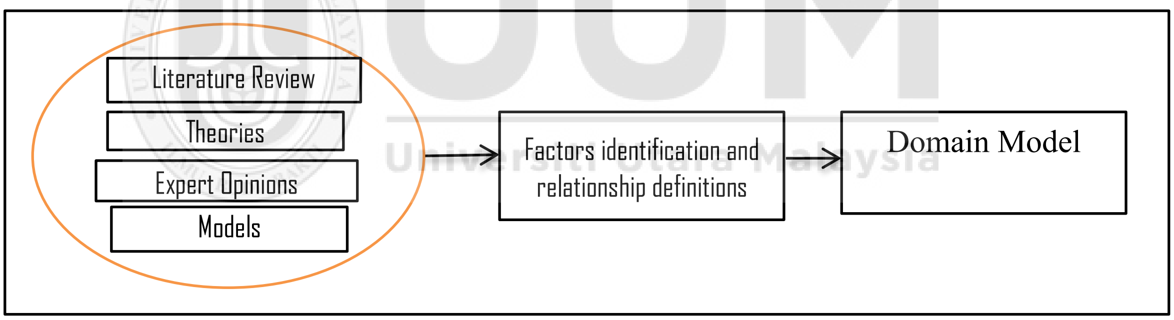

Figure 3.3. Domain model design

The outcome of this phase is the identified factors and relationships for self-efficacy, motivation and anxiety. The details of these constructs are presented and discussed in Chapter Four.

3.5.3 Design Model

This phase involves the symbolic representations of factors and identification of their relationships. All relationships between factors (both direct and indirect) are identified with flow arrows. The final design is the conceptual model for each of the constructs that would later be integrated to form the conceptual cognitive agent model. Figure 3.4 gives a sketch of the process involved in this stage.

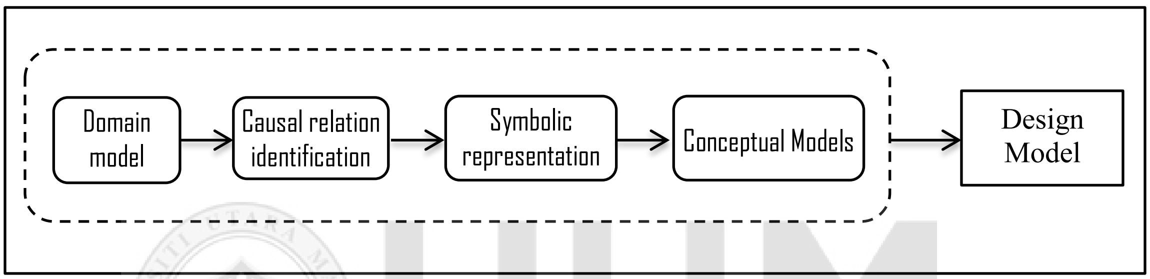

Figure 3.4. Design model schema

First, identified factors from theories and concepts are defined at this stage (e.g. symbolical representation). These symbolic representations of the entities of the model are aggregated to form a conceptual agent model with a set of exogenous input factors, state functions and outputs as explained in the domain model (Treur, 2016c).

For example, a mental state of being in a ―threat condition" (*Tr*) is typically caused by inadequate resources (*Rs*) to cope with the incoming event's demand (*De*) which can result to a worry (*Wr*) state. This event is amplified by the thought control (*Tc*) state. Figure 3.5 represents the cyclical causal model of this condition.

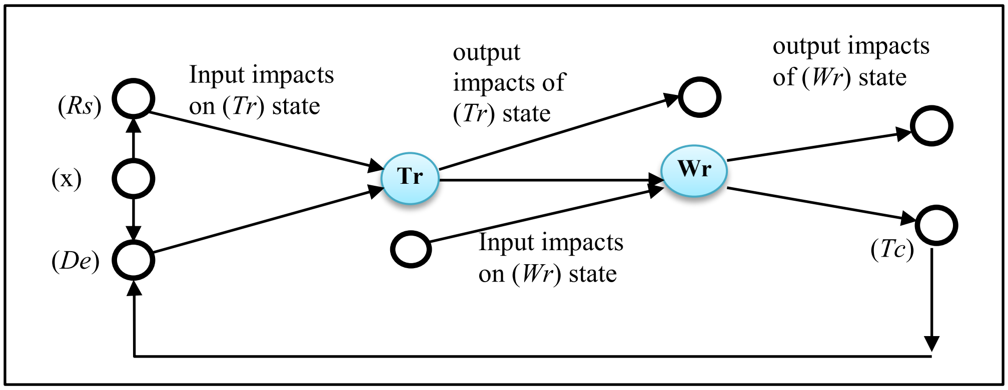

Figure 3.5. Mental states with their causal relations

From Figure 3.5, the dynamic feature of this type of state-defined model is enforced by its cyclic causality impacts. This implies that at each point in time activity takes place at each state simultaneously. For example, any change in *Tr* is influenced by *Rs* and *De* that later would affect *Wr*. This also later in turn would impact on *Tc* that subsequently influences *Tr*. The continuing state changes would result in reducing effects until no noticeable change, which is the state of equilibrium could observed (Treur, 2016c). The causal effects on state and nodes are mathematically derived from the dynamic equations in the operation phase explained in the next section.

3.5.4 Operational Model

The operational model is a final outcome which describes the mathematical (formal) relationships using differential equations that support quantitative analysis about interviewee behavioural constructs. Figure 3.6 shows the schema of the operational model.

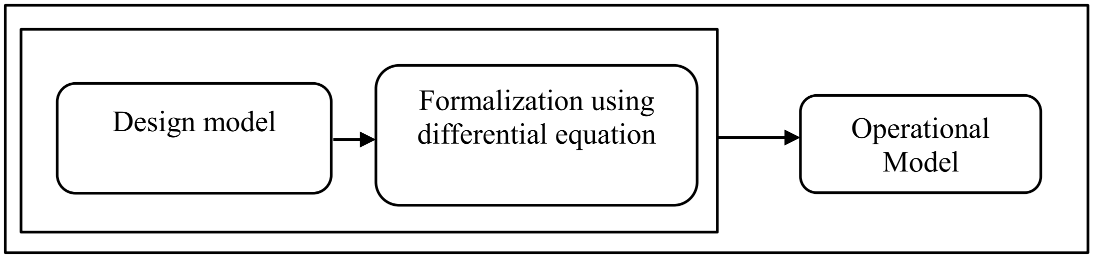

Figure 3.6. Operational Model schema

In this study, an operational model is developed by creating a set of differential equations to mimic behaviours of observed domain. This method has been used in Aziz, Klein and Treur (2009), Naze and Treur (2012), Li and Chan (2013), Noraziah, Aziz and Haneed (2016), and Janson and Marsden (2016). The sample of conceptual design in the previous section of design phase (Figure 3.5) is formally specified in this phase to demonstrate the operational design of the three agent models and the integrated model as will be explain in detailed in Chapter Four.

According to Treur (2016a), description of a conceptual representation of a dynamical model involves representing in a declarative manner the states and connections between them that represent (causal) impacts of states on each other, as has been determined in the factors identification and relationship definition in the domain model phase.

In determining such connections are considerations of the strength of the connection (i.e. the weight value of the edge), impacts on a state (combination function), and the speed of change (speed factor). In Figure 3.5 for instance, each of the connection from the input nodes *Rs* and *De* to state *Tr* has *weight values* ($\omega_{rs/de}$) representing the strength of the connection (where $0 \leq \omega_{x,y} \leq 1$). A *combination function* $C_{\mathbf{tr}}(Rs,..,De)$ combines the causal impacts of input states on to state *Tr* and a *speed factor* η_r is used to represent how fast a state *Tr* can change upon causal impact from the inputs

The model can be represented numerically though equations that are systematically generated in the following method;

At any time *t*, the state value of a state *Tr* is denoted by *Tr(t)*.

For the state *Tr* at each point in time *t*, each of the values *Rs(t)* and *De(t)* for the input states *Rs* and *De* connected toward *Tr* has a causal impact on the value of *Tr*. This principally resulted to the change in the value of *Tr* at the next point in time $t+\Delta t$. For each of the input states (*Rs* and *De*), this has influences on *Tr* at time *t* and it is proportional for both input values (*Rs(t)* and *De(t)*) and its connection weights $\omega_{rs/de}$.

The aggregated contributions (agCntr) of the values *Rs(t)* and *De(t)* at time *t* positively or negatively affects state *Tr* by pushing its value high or low. This is based on the computed differences between the aggregated contributions of the input states and the current value of *Tr* as shown in Equation (3.1) below.

$$Tr(t+\Delta t)= \text{agCntr}(Rs(t),De(t)) - Tr(t)).\Delta t \quad (3.1)$$

A positive difference in the above (for a small change in time, Δt), the value of state *Tr* will increase in the direction of the higher value agCntr(*Rs(t),De(t)*). The increase rate is proportional to the difference with a proportion factor $\boldsymbol{\eta}.\Delta t$ (Treur, 2016a). The entire comparison with time is depicted in Figure 3.7 where Tr = Y, agCntr($Rs(t)$...$De(t)$) = aggimpact$_{Y}(t)$ and $\boldsymbol{\eta} = \eta_{Y}$.

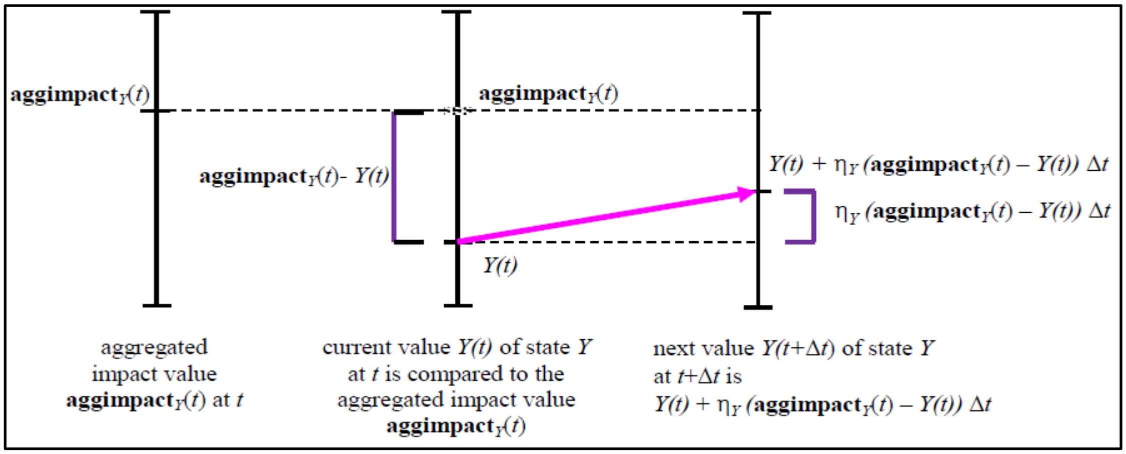

Figure 3.7. Impact of agCntr($Rs(t),De(t)$) on state $Tr(t)$ in time step from t to t+Δt (Treur, 2016a)

The numerical process discussed and structurally depicted above can be summarized by the following difference equation representation of the dynamical model:

$$Tr(t+\Delta t) = Tr(t) + \eta\, [(\omega_{rs} Rs(t) +, \cdots, + \ \omega_{de} De(t)) - Tr(t)]\, \Delta t \tag{3.2}$$

Applying these descriptions to the example in Figure 3.5, the relationships can be broken down into Equations 3.3, 3.4, 3.5, and 3.6 assuming the following assumption ensued from related theories;

(1) Threat (*Tr*) is increased by situation demand (*De*) but reduced by coping resources (*Rs*)

(2) Situation demand (*De*) is an aggregation between low thought control (*Tc*) and other factors (*X*)

(3) Worry (*Wr*) is developed by long time exposure of threat (*Tr*)

(4) Thought control (*Tc*) is reduced by the persistence of worry (*Wr*).

These can be organized into instantaneous equations (for states that are not varied with time) and temporal (for time varied states).

Instantaneous

$$Tc(t) = Tc(t).\big(1 - Wr(t)\big) \tag{3.3}$$

$$De(t) = \omega_{de}.\big(x_1(t) + \cdots + x_n(t)\big) + (1 - \omega_{de}).\big(1 - Tc(t)\big) \tag{3.4}$$

$$Tr(t) = \mathrm{De}(t).\big(1 - Rs(t)\big) \tag{3.5}$$

Temporal

From difference equation, the value of (*Wr*) in the current state can be predicated on its value from the previous state and the current change in combination function's values.

$$Wr(t + \Delta t) = Wr(t) + \eta_{wr}.\big(\mathrm{agCntr}(\omega_{x1}X_1 \ldots \omega_{xk}X_k) - Wr(t)\big).\Delta t \tag{3.6}$$

$where$ $\mathrm{agCntr}(\omega_{x1}X_1 \ldots \omega_{xk}X_k) = \omega_{wr}Tr(t) + (1 - \omega_{wr})Z$, and ω is the weight of the equation, and $\sum_{i=1}^{n} \omega_n = 1$

These equations serve basis for the development in a simulation environment that will generate the traces representing the expected behaviours.

3.5.5 Model Integration

The cohesive integration of the model is conducted by considering the relationships between the factors of the three underlying models. Since the constituents models are autonomous and also have overlapping factors, merging and composition integration techniques are used to integrate the models. Figure 3.8 depicts the schema of the integration.

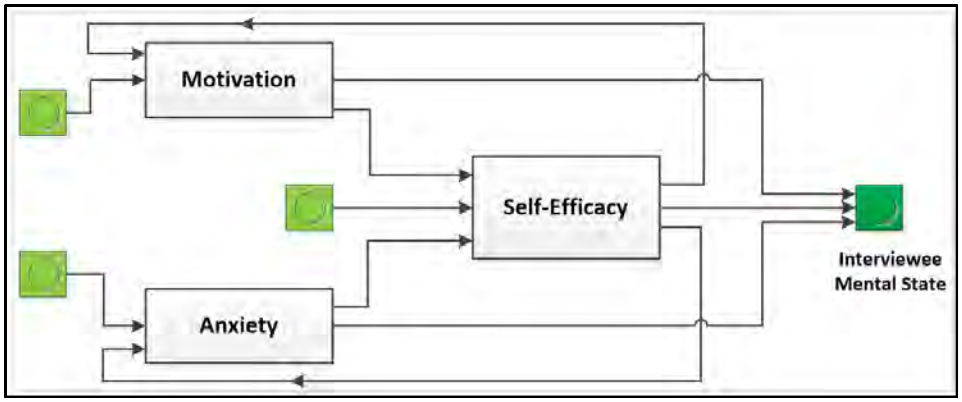

Figure 3.8. The architecture of the integrated interviewee mental states model

First, concepts in motivation and anxiety are combined with other factors to define self-efficacy whereas the efficacy level of an individual is a fundamental factor that shaping person's anxiety and motivation at that particular observed events. The dynamism of the integrated model is enhanced by a self-feedback loop that causes the complex cyclic intercommunication that stabilizes throughout time. The details of the integration are covered in Chapters Four and Five.

3.6 Demonstration

This stage involves practical demonstration of the designed solution. All formalized models are simulated by executing the generated codes on numerical programming platform (e.g. Matlab) to visualize their temporal dynamics and its interactions.

3.6.1 Simulation

Generally, the outcome of the simulation phase provides scientific reasoning which gives the fundamental behaviour of the formal model in the simulation environment. The model's input condition was varied over time to define the constructs and provide a better understanding of the behaviours under observation to see its conformity with theoretical foundations and empirical experiments. In this study, the visualization approaches through scientific graphs, and matrices are used to interpret the simulated results. Also, the observed results of the simulation are pointers to the correctness or otherwise of the manual designs of the previous stage. Figure 3.9 shows the activities in simulation stage.

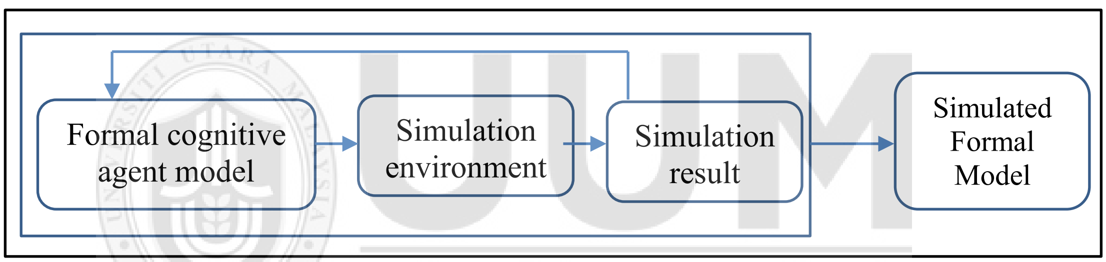

Figure 3.9. Simulation Process Activities

Within simulation environments, the executable model is simulated by assigning scenario of cases or conditions. While the three agent models individually harnessed the scenarios to prove the theoretical definitions, the integrated model is focused on the results to explain computational interplays between those three models. Generated simulation outputs (traces) based on defined cases are presented and discussed in Chapter Five.

In this example (using dummy examples), Table 3.1 shows the values assigned all exogenous (external) variables. The input scale is ranging from 0 (low) to 1 (high) and the simulation is executed on 500-time steps with step value Δt is defined to 0.2. In this example, all weights are assigned as 0.5 for situation demand equation, and a parameter for changing rate of the temporal variable is initialized as 0.2. The simulation trace based on the input values in Table 3.1 is shown in Figure 3.10. At this instance the parameter and weight assigned are merely for explanation of the expected simulation result.

Table 3.1

Exogenous Variable Values

Variable	Value
Task Demand (*Td*)	0.8
Basic Thought control (X_{tc})	0.3
Overall Resources (*Rs*)	0.2

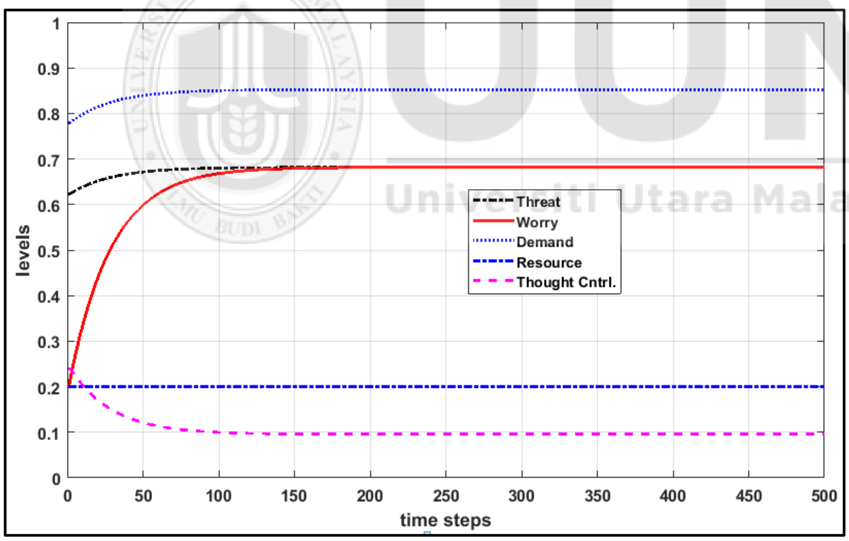

Figure 3.10. Simulation trace of the sample problem

The traces as shown in Figure 3.10 visualized the behaviours of the model. In this case, the threat value is high due to low resources (up to 0.2) taken to cope with overall high task demand (*Td* = 0.8). The trajectory shows that as threat value is increasing, the worry level has increased from 0.2 to 6.8 at time step, *t*= 200, where convergence has occurred.

3.7 Evaluation

Evaluation phase can be categorized into two parts, verification and validation. Figure 3.11 depicts the structure of evaluation.

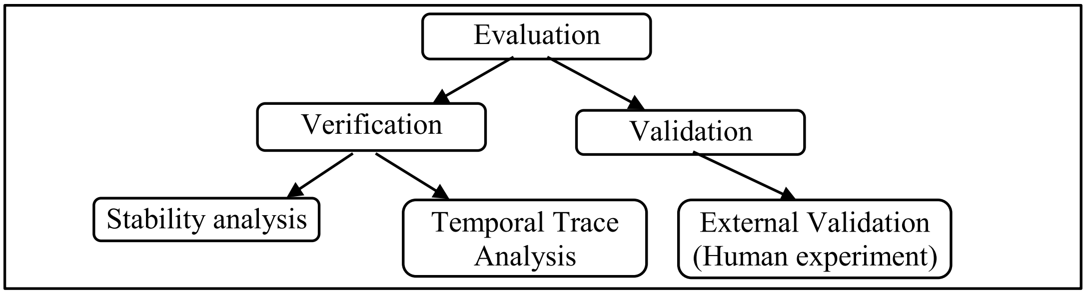

Figure 3.11. Evaluation Schema

3.7.1 Verification

The study adopts two verification methods, 1) mathematical verification using stability analysis and 2) automatic verifications using temporal trace language. Figure 3.12 depicts the flow of the process of verification used.

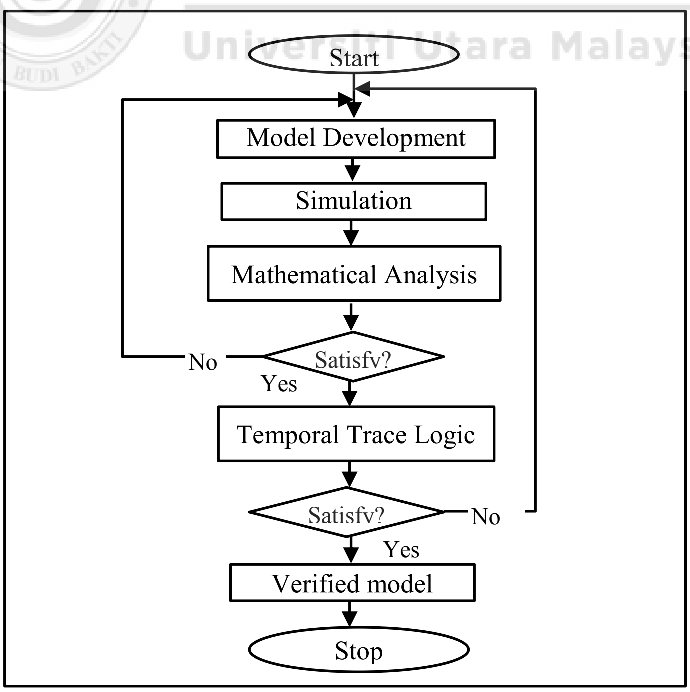

Figure 3.12. The flow of a model verification process

Mathematical Analysis

Mathematical analysis is basically performed to ensure all syntax and semantic representations used in the formal model are consistent. A number of mathematical analyses types exist, such as real analysis, complex analysis, functional analysis, differential equation analysis, measurable analysis, stability analysis and numerical analysis (Lebedev, Vorovich, & Cloud, 2013). Also known as equilibria analysis, stability analysis is adopted due to the need to check the stability of finite specifications in the developed models. This analysis is based on Fourier decomposition of numerical error which addresses trajectories of the model under any small distress conditions. Also, this approach is able to detect errors even with a small disturbance (Das, Goswami, Chatterjee, & Mukherjee, 2014). Many studies have adopted this technique, such as Bosse, Both, et al., (2011); Das & Hanaoka, (2014); Naze & Treur, (2012) and Noraziah et al., (2016).

Stability analysis allows the equilibrium or stationary point of a model to be determined, by determining the values for the variables for which no change occurs. The occurrence of equilibria point can be analysed from the difference or differential equations describing the dynamics of the model (Treur, 2016d). It can be found when a certain state is increasing or decreasing where a state is not in a stationary point or equilibrium. First, a definition of these notions is as expressed below;

Let Y be a state

- Y has a *stationary point* at t if $\mathrm{d}Y(t)/\mathrm{d}t = 0$
- Y is *increasing* at t if $\mathrm{d}Y(t)/\mathrm{d}t > 0$
- Y is *decreasing* at t if $\mathrm{d}Y(t)/\mathrm{d}t < 0$

The model is in *equilibrium* at t if every state Y of the model has a stationary point at t. Generally, in order to obtain possible equilibrium values for variables, first the model is described in a differential equation form:

$$\frac{dy}{dx} = f(x, y).$$

Next, the equations are identified describing

$$\frac{dy}{dx} = 0$$

For instance, this notion as applied in the sample design in the previous section formalized, simulated and presented in Figure 3.10;

The differential equation

$$Wr(t + \Delta t) = Wr(t) + \eta_{wr}.\left(\text{agCntr}(\omega_{x1}X_1 \ldots \omega_{xk}X_k) - Wr(t)\right).\Delta t \qquad (3.7)$$

Can be re-written thus

$$dWr/dt = \left(\text{agCntr}(\omega_{x1}X_1 \ldots \omega_{xk}X_k) - Wr(t)\right)$$

Where $\text{agCntr}(\omega_{x1}X_1 \ldots \omega_{xk}X_k) = Tr(t)$

Since $\frac{dWr}{dt} = 0, then$ stability is a point when $Tr(t) = Wr(t)$

This case of $Tr = Wr$ can be analysed from Tc equation feeding from Wr

$$Tc = X_{tc}.(1 - Wr) \qquad (3.8)$$

$$Tc = X_{tc}.(1 - Tr)$$

This can be explained that at equilibria point the value of Tc is equal the product of X_{tc} and the opposite contribution of threat. Sample stability point is shown in the point of convergence of plot lines in Figure 3.12. At this point the cyclic change in the dynamic factors is zero.

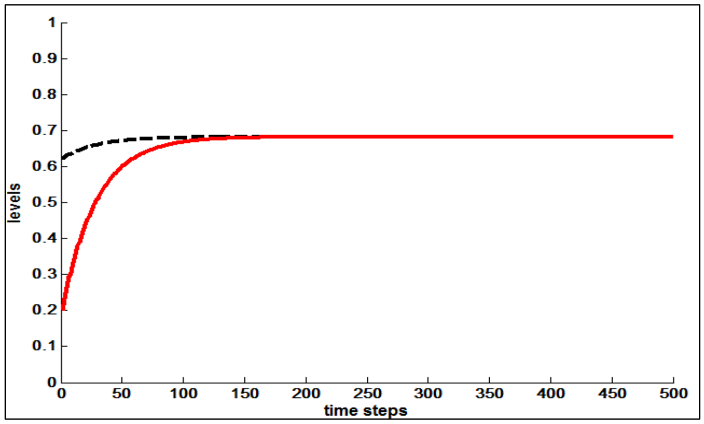

Figure 3.13. Example simulation showing stability points

Automatic Verification

Temporal Trace Language (TTL) is used for the automatic verification of the model. It is suitable for formal specification and analysis of dynamic properties of models and systems. The language supports specifications of both qualitative and quantitative aspects and subsumes languages based on differential equations and temporal logics with a high expressivity and normal forms that enable automated analysis (Sharpanskykh & Treur, 2010). TTL is a logical language and variant of order-sorted predicate logic. It is an extension of standard multi-sorted predicate logic explicitly for representing dynamic properties of systems.

The cases where this method is employed in this study are normal situations requiring a check of properties on a few sets of traces obtained by simulation. It is assumed that the sets of expressions defined by state language and the TTL are disjointed. Therefore, the same notations for the elements of the object language and for their names in the TTL are used in TTL formulae without any form of ambiguity being introduced. Additionally, *t* with subscripts and superscripts for variables of the sort *TIME*; and γ with subscripts and superscripts for variables of the sort *TRACE* are used. For example;

A state is described by a function symbol *state*: $TRACE \times TIME \rightarrow STATE$. A trace is a temporally ordered sequence of states. A time frame is assumed to be fixed, linearly ordered, for example, the natural or real numbers. The set of function symbols of TTL includes $\rightarrow$, $\leftrightarrow$, $\vee$, $\wedge$ (infix notation) and $\forall, \exists$ (in prefix notation). States are related to state properties via the satisfaction relation denoted by the prefix predicate holds (or by the infix predicate |=): holds (state(γ , *t*), p) (or state(γ , *t*) |= *p*), which denotes that state property *p* holds in trace γ at time point *t*. Both *state*(γ , *t*) and *p* are terms of the TTL language. Taking the example from this chapter, the TTL properties for temporal evaluation between threat and worry cases could be represented as:

VP1: High Threat Increases Future Worry

VP1 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀R1,R2,D1,D2:REAL
[state(γ,t1)|= has_value(threat, R1) &
state(γ,t2) |= has_value(threat, R2) &
state(γ,t1)|= has_value(worry, D1) &
state(γ,t2)|= has_value(worry, D2) &
t1 < t2 & R1 > 0.5 & R2 ≤ R1] ⇒ D2 ≥ D1

Therefore it implies that TTL terms are generally constructed by standard induction from variables, constants and function symbols typed with earlier described TTL sorts. Transition relations between states are described by dynamic properties, which are expressed by TTL-formulae (Sharpanskykh & Treur, 2010).

3.7.2 Validation

Validation provides answers to the question of whether the right model is built. This research adopts *Predictive Validation* technique, a form of an operational validation approach, used in determining whether the simulation model's output behaviour has the accuracy required for the model's intended purpose over the domain of the model's intended applicability (Sargent, 2011). This comparison involves relating the simulation model's output to the behaviour of human system (interviewee behaviours in terms of the disposition of the three constructs of self-efficacy, motivation and anxiety) using graphical displays and statistical tests and procedures. Studies that have applied this method can be seen in (Majid, Aickelin, & Siebers, 2009; Morecroft & Robinson, 2006; Siebers, 2008). The operational validation of the integrated model detailed in the section that follows (Section 3.8), answers the final research question and achieves the last objective of the research.

3.8 Operational Validation Experiment

This involves checking of the simulated results of the integrated cognitive agent model to ensure its conformity with the output of real live system it is design to emulate. The real-life system in our case is the human (interviewees) confronted in an interview environment with interviewers. The activity flow in Figure 3.13 is adapted to guide the experimental protocol of the validation experiment.

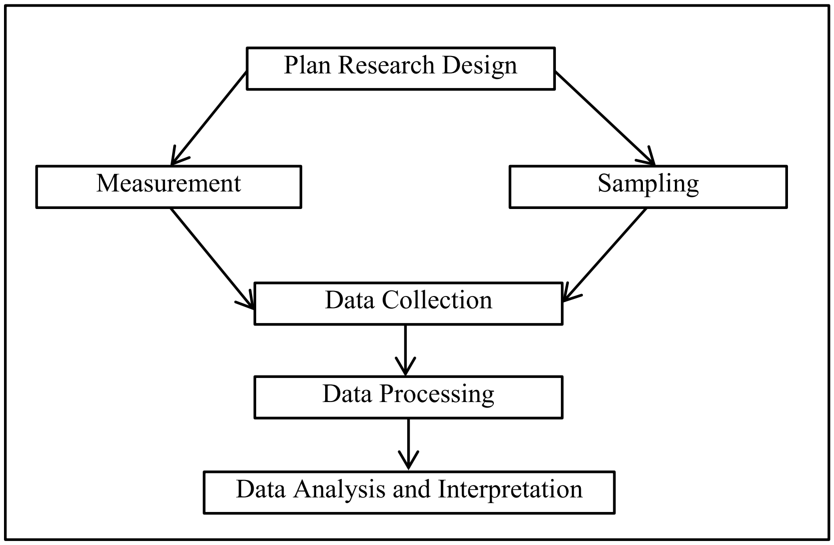

Figure 3.14. Experiment activity flow (Singleton & Straits, 2010)

The purpose of the study is to evaluate the veracity of the integrated model operationally using human experiment. The hypotheses to drive the research are as stated;

Hypothesis

H_0: The human and simulated model outputs of anxiety, self-efficacy and motivation are not significantly different.

H_1: The human and simulated model outputs of anxiety, self-efficacy and motivation are significantly different.

The three fundamental constructs hypothesized to define the interviewee state of mind during interview session (self-efficacy, motivation and anxiety) (Huffcutt et al., 2011) were found to be appropriately projected in the simulation trajectories. For example, an efficacious personality is likely to be motivated and less anxious during interview session, especially where the control variables (task difficulty, interviewer disposition and verbal persuasion) are kept constant by interviewer per interviewee.

3.8.1 Experiment Design

The study adopts predictive validation technique to validate the integrated agent model. *Predictive Validation* is used to predict the system's behaviour, and then comparisons are made between the system's behaviour (in our case human) and the model's forecast to determine if they are the same (Sargent, 2011). The human data comes from the field experiment conducted. It is a quantitative design approach involving the use of an adopted standardized questionnaire to measure certain personality and environmental factors of interviewee both before and after the simulated interview session. The values obtained at the pre-interview serves as the input values for the simulation. The post-interview values are compared with the result of the simulation to test for the rejection of the null hypotheses on the three basic constructs of self-efficacy, motivation and anxiety of the interviewee during the interview. A black box validation (Treur, 2016d) method where a simple comparison of the simulation outputs with the real system outputs in terms of quantities for hypotheses testing.

3.8.1.1 Sampling Methods

The target population is final year undergraduate student of a higher institution of learning. Sample participants are categorized into two, the interviewees (*N*=36) and the interviewers (*N*=4). The experiment used multistage sampling technique. This type of sampling technique involves sampling at different stages of selecting the appropriate samples for the experiment (Singleton & Straits, 2010). The unit of analysis in this experiment is final year students.

3.8.1.2 Measurement / Instrumentation

The key variables in this study are measured by self-reported questionnaires. The standardized instruments are generally adopted; however, some items are tinkered in some instruments (e.g. Generalized Self-efficacy Scale) so as to adapt to the specificity of the interview situation. Table 3.2 below presents the instrument used to measure the variable.

Table 3.2

Constructs Measuring Instruments

Factors	Instrument	Scale	References
Personal Autonomy	Index of Autonomous Functioning (IAF) Scale	5	(Weinstein, Przybylski, & Ryan, 2012)
Assertiveness (Personality)	Short Form of Simple Rathus Assertiveness Scale SRAS-SF	6	(Jenerette & Dixon, 2010)
Social support	Multidimensional Scale of Perceived Social Support	7	(Zimet, Dahlem, Zimet, & Farley, 1988)
Trait Anxiety	State-Trait Anxiety scale (part 2)	4	(Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1977)
Relatedness	Need for Relatedness Scale	7	(Richer & Vallerand, 1998)
State Anxiety	State-Trait Anxiety scale (part 1)	4	(Spielberger et al., 1977)
Self-Efficacy	Generalized Self-efficacy Scale GSE	4	(Schwarzer & Jerusalem, 1995)
Motivation	Short Form of Questionnaire on Current Motivation (QCM)	7	(Freund, Kuhn, & Holling, 2011)

The adopted standardized measuring instruments are included in Appendix B. The reason for adopting these standardized instruments is based on the fact that all input factors to be measured by the integrated model and the temporal factors have severally been studied in psychology and social science research where these designed and well tested instruments are used. The detail description of each of the instruments including the internal reliabilities is given in Section 6.6.1 (Experiment Details).

3.8.1.3 Method of Data Collection

The experiment was conducted in three phases which are pre-interview, interview and post-interview phases. In the pre-interview phase, selected participants were invited through phone calls to a seminar room in Chemical Engineering department. They were properly briefed on what the pre-interview instruments were meant to achieve and how they are expected to complete the instruments. The briefing was done in junction with two volunteer staffs of computer science department who have received briefing earlier on the experiment and all the instruments. Their duty was to assist in the distribution of questions and attending to any respondent with specific questions or concerns while the process was ongoing.

The pre-interview questionnaire consists of instruments to measure (i) prior interview experience, (ii) vicarious experience, (iii) personal autonomy, (iv) assertiveness, (v) social support, and (vi) trait anxiety. The items of the instruments were read one after the other and explained to the understanding of the participants. These questions were explained and discussed thoroughly to the satisfaction of all before moving to the next item. This allows the respondents to be able to provide more accurate answers to the selfreporting questions. The participants responded according to their individual feelings, views or experience to the items.

The interview phase is organized to take place at the Administrative block of the department of Computer Science in order to further simulate a real job interview environment. The interview was conducted two days after the opening session where the pre-interview instruments were filled. Interviewers were asked not to engage in any form of rapport building with the participants. Four rooms were used for the interview with each interviewer to a room to avoid distraction and interference. Interviewees (respondents) were invited to the interview via phone calls with scheduled time. On arrival, they were allocated randomly to any of the interview room that is vacant.

The interview questions are of two categories. The first is meant to be difficult and the other simple. Each category consists of five sets of interview questions such as ―Can you introduce yourself?". Each interview lasted for approximately 10 minutes in length. The three control variables are the Interviewer Disposition (perceived relatedness), Task Demand (difficult or simple questions), and Verbal Persuasion (low or high). Two interviewers acted strict and tough while the other two acted easy and calm. Table 3.3 below shows the value distribution of the three variables to control the interview process.

Table 3.3

Control Variable Values

Interviewer	Interviewer Disposition	Task Demand	Verbal Persuasion
A	Low	Low	Low
	Low	Low	High
B	Low	High	Low
	Low	High	High
C	High	Low	Low
	High	Low	High
D	High	High	Low
	High	High	High

Table 3.3 shows the respondents mix according to interviewer disposition, task demand and verbal persuasion. Low disposition describes unfavourably disposed interviewer while high disposition is opposite. Low task demand represents simple tasks (question) where high tasks are difficult tasks. The absence of verbal persuasion during the interview is low whereas the existence of persuasion is high.

The third phase involves administering the post-interview questionnaire to the interviewees. The post-interview questionnaire consists of instruments to measure 1) task demand, 2) verbal persuasion, 3) perceived relatedness (interviewer disposition), 4) interviewee motivation, 5) state anxiety and 6) interviewee self-efficacy. Respondents are reminded to fill their registration numbers on the post-test so as make the matching easy for coding purpose.

3.8.1.4 Method of Data Analysis

The tool used is a multivariate statistical method, Hotelling's T^2 distribution, which is used for testing the multivariate hypothesis (Manly & Alberto, 2016; Sparks, 2014). The Hotelling's T^2 distribution is a multivariate statistical technique used for test of a hypothesis concerning mean vectors. In this case, the two multivariate normal populations are the Human Outputs and Model simulation Outputs; each having three variables, anxiety, self-efficacy and motivation. In order to test the null hypothesis concerning two multivariate normal populations where the difference is zero; we proceed as follows.

$$\mathbf{H_0} : \boldsymbol{\mu}_1 = \boldsymbol{\mu}_2$$
$$\mathbf{H_1} : \boldsymbol{\mu}_1 \neq \boldsymbol{\mu}_2$$

In this case; $\boldsymbol{\mu}_1$ and $\boldsymbol{\mu}_2$ are the means of human outputs and model simulation outputs respectively. Based on random samples of sizes *36* students each, from human outputs and model simulation output populations respectively; the test statistic is as follows:

$$T^2 = \frac{n_1 n_2}{n_1 + n_2}(\overline{\mathbf{X}}_1 - \overline{\mathbf{X}}_2)' \mathbf{S}_\mathbf{p}^{-1}(\overline{\mathbf{X}}_1 - \overline{\mathbf{X}}_2) \tag{3.9}$$

The formula above is the two-sample Hotelling's T^2 distribution; if the observed T^2 exceeds the critical value, the null hypothesis is rejected. In this case, $\overline{\mathbf{X}}_1$ and $\overline{\mathbf{X}}_2$ denote the sample means from human outputs and system outputs populations. The three variables in each mean vectors are anxiety, self-efficacy and motivation respectively. While, $\mathbf{S}_\mathbf{p}$ is the pooled sample covariance matrix.

3.9 Communication

This stage is the last step which involves report writing and communication of findings. Academic papers are generated from the research, presented and published in relevant local and international conferences and journals. The entire report is presented as this thesis.

3.10 Summary of the Chapter

This chapter has explained the study methodology applied to answer the five research questions mentioned in Chapter One. The study is based on Design Science Research Processes (DSRP) framework and Agent-Based-Modelling (ABM) approach. The framework consists of six stages, namely; problem identification and motivation, the objective for the solution, design and development, demonstration, evaluation and communication. The extensive literature on theories and concepts related to the domain (cognitive behavioural dynamics of interviewee during interview session) were harnessed in the first two stages so as to define the motivations and objectives of the research. Design and development constitute the description of methods and processes adopted to design each of the agent models and formalizing them. Agent-Based Modelling (ABM) approach which addresses the model design based on three phases of domain, design and operational model phases were described. Model integration processes involving internetworking of the agents to the integrated cognitive agent model is equally described at this stage. The description of how the formalized models were translated into simulation environment and executed using simulation numerical analysis language (e.g. MATLAB) was done in demonstration stage. Evaluation stage describes the tools and processes for verification and validation of the model to ensure the veracity of the model and communication stage captured the report of the research and publications.

Table 3.4 shows the summary of each stage as well as the methods/ tools employed to accomplish them.

Table 3.4

Summary of Research Methodology Stages

Stage	Method/Tool	Outcome	Objectives
Problem identification and motivation	Literature Review	Problem statement	-------
The objective for the solutions	Literature Review	Identified factors for the conceptual model.	Obj. 1
Design and development	Agent-Based Modelling technique, differential equation	(i) Formal models of Self-efficacy, motivation and anxiety constructs. (ii) Integrated cognitive agent model of interviewee mental state	Obj. 2 & 3
Demonstration	simulation tools - MATLAB	Simulated model & integrated model	Obj. 2 & 3
Evaluation	Mathematical verification (stability analysis), automated verification (TTL), and validation (operation validity/predictive technique)	Evaluated Models	Obj.2 & 4
Communication	Publications	Conferences/journals and Thesis report	________

CHAPTER FOUR

MODEL DEVELOPMENT AND INTEGRATION

4.1 Introduction

This chapter discusses detail on the development of the agent based models of the three constructs and the integrated model using the methodology presented in Chapter Three. The phases and activities undertaken to develop the models such as the domain, design and operations phases are clearly stated in the chapter in sections and sub sections. The Integration of the three agent models into a cognitive agent model is clearly depicted in the chapter also.

4.2 Underlying Concepts in Modeling Process

In this study, the fundamental premise upon which the state influence of an interviewee has been defined stands on the interplays between the three constructs of self-efficacy, motivation and anxiety. Achieving the conceptual model of the three constructs involves extensive literature in the domain of cognitive modelling and human psychology where relevenat theories are explored. The papers, theories and concepts reviewed are represented in Table 4.1

Table 4.1

The Summary of Major Reviewed Sources for the Constructs

Construct	**Main Sources**	**Theories**
Self-Efficacy	Ahn, Bong, and Kim (2017); Bandura (1982); Bandura (1986); Bandura (1989); Barrows, Dunn, and Lloyd (2013); Holmes (2016); Lunenburg (2011); Luszczynska, Gutiérrez-Doña, and Schwarzer (2005); Pajares (1997); Schunk (1991); Schunk (1995); Schunk and Pajares (2009)	Social Cognitive Theory, Self-efficacy theory, Goal Theory and Schunk's Model of Self-efficacy and Motivation.
Motivation	Bencsik, Machova, and Hevesi (2016); Fonseca, Blascovich, and Garcia-Marques (2014); Gnambs and Hanfstingl (2016); Graham and Weiner (1996); Hulleman, Barron, Kosovich, and Lazowski (2016); Kelley and Michela (1980); Pajares (2009); Piniel and Csizér (2013); Schunk (1995); Weiner (2013); Weinstein, Przybylski, and Ryan (2012); Wigfield and Eccles (2000); Yee and Braver (2018)	Expectancy-value Theory, Self-determination theory, Social cognitive theory, Goal theory, Flow theory, and Unified Theory of Task-specific Motivation.
Anxiety	Berenbaum (2010); Borkovec, Alcaine, and Behar (2004); Ellis and Hudson (2010); MacDorman and Entezari (2015); Katalin Piniel and Csizer (2015); Katelin Piniel and Csizér (2014); Tahmassian and Moghadam (2011); Wells (1999, 2005)	Test-taking Anxiety Theory, Generalized Anxiety Disorder Theory, and Social Cognitive theory.

These reviews made provisions for the factors identified for building the domain models. The identified factors (Self-efficacy=24, Motivation=22, Anxiety=16) are used to construct the conceptual models of their respective agent models, and the bases for integration.

4.3 Construction of the Constituent Agent Models

This section presents the construction process of self-efficacy, motivation and anxiety models will be integrated into a monolithic cognitive agent of interviewee. Each construct followed the fundamental phases in model development (i.e., domain, design and operational phases) as earlier explained in Chapter 3 (Sections 3.5). The components of the designs are operationalized separately to allow for all-inclusiveness and flow of the process.

4.3.1 Interview Self-Efficacy Agent Model

Self-efficacy model is built from identifying factors from theories and concepts of self-efficacy construct that is related to the domain of task specific situation such as in job interview. This part consists of 4 sub-sections where the first identified the factors which represent the domain model of self-efficacy as summarized in Table 4.1. The following sub-section presents the designs of the related entities of the conceptual model (Figures 4.1 to 4.6) with relevant formalization equations (instantaneous relation equations) (Equation 4.1 to 4.14). The third Section presents the conceptual model of the interviewee self-efficacy (Figure 4.7) and followed by the final sub-section on formalization of the temporal dynamics of the model (Equations 4.15 to 4.17).

4.3.1.1 Identification of Causal Factors

Relevant factors that causally build to self-efficacy construct are identified from the main theories (SCT and PTC) and reviewed concepts relating to interview domain. By definition, self-efficacy is the ―personal judgment of ability to organize and execute a cause of action required in a prospective situation" (Barrows et al., 2013).

Fundamentally, self-efficacy is premised on the belief of personal capacity to execute a task in a given situation by exerting necessary efforts and persevering when confronted with challenges and impediments (Bandura, 1997). This underlying construct is based from the foundation of *Social Cognitive Theory,* an approach to understand human cognition, action, motivation, and emotion that assumes that humans are active shapers rather than simply passive reactors to their environments (Wood & Bandura, 2013). In addition, it affects the choice of activities, efforts exerted, level of persistence, and achievement (Cherian & Jacob, 2013).

Specifically, the interview self-efficacy is the confidence an interview candidate has in his/her ability to favourably do well in an interview session. This is influenced by factors such as prior experience (in similar event), motivation (internal or external drive), anxiety, social support, cognitive ability and skills(Schunk, 1995). Factors such as goal, efforts towards goals and situational issues like feedback on goals generally make efficacious person to set more challenging goals (Sitzmann & Ely, 2011; Jeffrey B. Vancouver et al., 2014), works harder (*effort*), (Schmidt & DeShon, 2010), persists longer when faced with challanges (*persistence*) (Jeffrey B. Vancouver & Purl, 2017) and attains a higher level accomplishment (*task performance*) (Schmidt & DeShon, 2010; Yeo & Neal, 2013) than those who are not. Furthermore one's self-regulation is generally accepted to be critically affected by self-efficacy (Sitzmann & Ely, 2011).

It begins when individuals obtain information to assess the inherent self-efficacy from their prevous performances in similar task (*mastery*), vicarious experience (*observational*), persuasion received, and physiological responses. Efficacy information affects final efficacy lebel through a process involving self-evaluation (*appraisal*). *Personal goal* is a main action determinant and central to all achievement related models, contributes towards appraisal, task efforts, and final self-efficacy belief (Bandura, 1997). *Effort* can be enhanced by a self-motivated individual with a positive belief in ability (*self-efficacy*) or an attribution to positive feedback. Consequently, individuals in a demanding situation and getting a feel of achievement through positive feedbacks would tend to exert more commitments to get the job done. This extend to which one is willing to continuously commit to get the job done is defined by *cognitive engagement* and it correlates with persistence. However, high persistence over time may not necessarily result in a commensurate level of cognitive engagement as engagments can decay over time (Park & Roedder, 2014). Table 4.1 below presents the overall identified factors to be used as a building block for the conceptual model in self-efficacy and interview task.

Table 4.2
Identified Interview Self-Efficacy Factors

	SN	Concept	Notation	Description	Reference
Input Factors	1	Anxiety	*Ax*	Feeling of apprehension before or during a task	(Barrows et al., 2013)
	2	Verbal persuasion	*Vp*	Efficacy information from encouraging remarks of especially the interviewer	(Barrows et al., 2013)
	3	Vicarious Experience	*Ve*	Efficacy information of success witnessed from related personality on the interview	(Lunenburg, 2011)
	4	Social support	*Ss*	Support from close associates	(Schunk, 1995; C.-M. Wang, Qu, & Xu, 2015)
	5	Personality	*Pn*	Quality of being self-assured and confident without being aggressive	(Cook, Vance, & Spector, 2000a)
	6	Mastery Experience	*Me*	Positive prior experience in an interview or related task	(Lunenburg, 2011)
	7	Task Demand	*Td*	A need to be resolved by a specific working effort	(Fonseca et al., 2014)
	8	Interview Skill	*Sk*	This is the know-how developed from knowledge and practice	(Hayes et al., 2015)

Table 4.2 Continued

Internal factors	9	Affective state	*As*	Subjective feelings	(McQuiggan et al., 2008)
	10	Efficacy Information	*Ei*	Collection of information during a task that can boost or reduce one's efficacy belief.	(Holmes, 2016)
	11	Experience	*Ep*	Defined as the combination of mastery and vicarious	(Lunenburg, 2011)
	12	Basic Efficacy	*Be*	Initial efficacy before one engages in a task	(Schunk, 1995)
	13	Perceived Task Difficulty	*Pd*	Task demand relative to resources to cope with the task	(Eysenck & Calvo, 1992)
	14	Efficacy Appraisal	*Ea*	Evaluation of personal believes in one's ability	(Ahn et al., 2017)
	15	Personal Goal	*Gp*	Broad personal desire	(Schunk, 1995; Vancouver et al., 2014)
	16	Generated Effort	*Gf*	Created energy to meet task demand	(Bosse, Both, et al., 2011)
	17	Mental Effort	*Mf*	Amount of cognitive resources that have to be devoted to obtaining relevant outcomes	(Chow, Hui, & Lau, 2015; Schunk, 1991)
	18	Progress Towards Goal	*Pg*	Goal achievement or progress judgment	(Seo et al., 2004)
	19	Cognitive Engagement (Short-term and Long-term)	*Se* and *Le*	Psychological investment in and effort directed towards solving the task at hand	(Board, 2016)
	20	Persistence (Short-term and Long-term)	*Sp* and *Lp*	Personal commitment or perseverance on task	(Schunk & Pajares, 2009); (Cherian & Jacob, 2013)
	21	Self-Efficacy (Short-term and Long-term)	*Sf* and *Lf*	Belief in one's ability to engage in course of action necessary to solve a specific task	(Barrows et al., 2013)

4.3.1.2 Entities of Self Efficacy Agent Model

From the identified factors in Table 4.1, the causal relationships of the entities that make up the conceptual model of self-efficacy are defined. The diagrams showing the connections of the factors in an aggregated format are shown in Figures 4.1 to 4.6. The formalization of each of the model is the derived equation (Equations 4.1 to 4.14) for all the relationships in the respective component designs.

Basic Efficacy (*Be*)

Basic efficacy is related to the interviewee the initial belief on ability (basic efficacy) (*Be*) based on previous experience (*Me)* on a similar task, social support (*Ss*) (e.g. family and close associates), and assertive component of personality (*Pn*) factors (Ahn et al., 2017; Schunk, 1995). These factors contribute positively as represented in Figure 4.1 while Equation 4.1 shows the formalization.

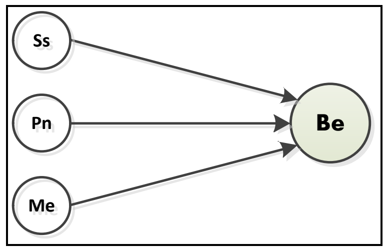

Figure 4.1. Basic Efficacy

Formalization

Basic efficacy (*Be*) is causally subjective to the contributions of social support (*Ss*) and mastery experience (Me), but regulated by assertive personality (*Pn*).

$$Be(t) = \left(\beta_{be}.\mathrm{Ss}(t) + (1 - \beta_{be}).Me(t)\right).\left(Pn(t)\right) \tag{4.1}$$

Affective State (*As*), Efficacy Information (*Ei*), and Experience (*Ep*)

Generally, the affective state (*As*) refers to the experienced negative emotion that is amplified by the trait anxiety (*Ax*) and reduced by the level of basic efficacy belief (*Be*) (e.g. previous experiences in interview tasks) (Jeske et al., 2018). From this concept, more experiences are able to reduce the harmful effects of the affective state.

During task engagement, information (*Ei*) is received to boost one's efficacy through mastery experience (*Me*), vicarious experience (*Ve*), verbal persuasion (*Vp*), and physiological cues defined as affective state (As) (Lunenburg, 2011). Mastery experience (*Me*) and vicarious experience (*Ve*) are represented as experience (*Ep*) which serves to reinforce (*Ei*) as earlier stated. Figure 4.2 shows causal relations in (*As*) and (*Ep*) to (*Ei*) entity and the formalization is shown in equations 4.2 to 4.5.

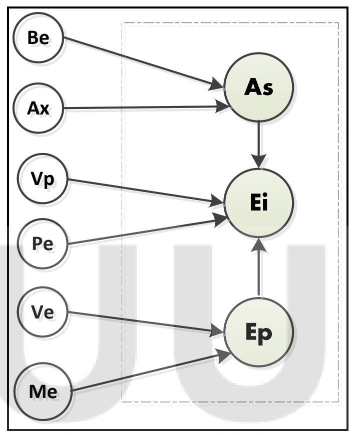

Figure 4.2. *As*, *Ep*, and *Ei* relationship block

Formalization

Affective State (*As*) is a function of anxiety state (*Ax*) of an individual and the basic efficacy(*Be*). General experience (*Ep*) is derived from the contributions of Mastery experience (*Me*) and Vicarious experience (*Ve*). These two contributing experiences (i.e., mastery and vicarious) could be positive or negative depending on how they are acquired. Vicarious experience (*Ve*) is related to the level of expertise, the status and the relationship shared with the personality the experience is being acquired. Efficacy information (*Ei*) is however positively influenced by verbal persuasion (*Vp*) and general experience (*Ep*) but negated by the strength of affective state (*As*).

$$As(t) = Ax(t).\left(1 - Be(t)\right) \tag{4.2}$$

$$Ep(t) = \omega_{ep}.\mathrm{Me}(t).\left(1 - \omega_{ep}\right).Ve(t) \tag{4.3}$$

$$Ei(t) = \left(\alpha_{ei}.\mathrm{Ep}(t) + (1 - \alpha_{ei}).Vp(t)\right).\left(1 - As(t)\right) \tag{4.4}$$

Interview Skill (*Sk*) and Perceived Task Difficulty (*Pd*)

Skills are acquired with persistence on a task on a long-term to achieve a result. The basic skills (Sk_{norm}) one takes to participate in a given task (e.g. interview session) can be developed if there is perseverance and commitment to the task, for example through interview coaching or mock interviews (Hayes et al., 2015; Maurer, Solamon, Andrews, & Troxtel, 2001). Perceived task difficulty (*Pd*) can be defined through the demand imposed by the interview (*Td*) and the resources available for the interviewee to handle it. The experience acquired on interview task for instance and the personal interview skills developed through the experience constitute the available resource while helps to reduce perceived task difficulty. The causal relationship of the above detail is shown in Figure 4.3 and the formalization in Equations 4.5 and 4.6.

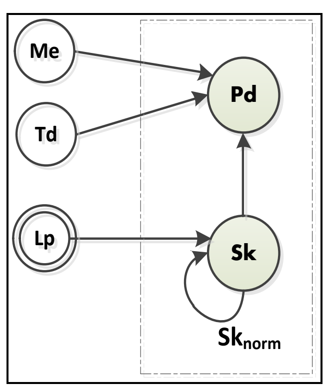

Figure 4.3. Skill and Perceived Task Difficulty

Formalization

Skill (*Sk*) is computed through the regulation of initital skills (Sk_{norm}) possesed by the individual and persistence on long-term (*Lp*). Contributions of Mastery experience (*Me*) and Task demand causally define the Perceived task difficulty (*Pd*) which can be regulated by skill.

$$Sk(t) = \gamma_{sk}.Sk_{norm}(t) + (1 - \gamma_{sk}).Lp(t) \tag{4.5}$$

$$Pd(t) = \left(\omega_{pd1}Me(t) + \omega_{pd2}Td(t)\right).\left(1 - Sk(t)\right) \tag{4.6}$$

Efficacy Appraisal (*Ea*), Personal Goal (*Gp*) and Short-term Persistence (*Sp*)

Efficacy is appraised within the context of self-evaluation on belief about self-ability. During interview task, for instance, the interviewee unconsciously perform self-evaluate of his/her abilities based on the information obtained internally from basic efficacy (*Ei*), personal goal (*Gp*), effort available for the task (*Mf*) and feedback from engagement overtime (*Le*) on the interview (Ahn et al., 2017).

Personal Goal (*Gp*) is the broad personal desire at the task and can be positively affected by the level of progress made to achieve the goal (*Pg*). That is, when a progress is seen to be made on the task, personal desire to meeting the target is strengthened (Lunenburg, 2011). Additionally Basic efficacy (*Be*) and experience (*Me*) positively build on the goal but the aggregation is reduced by perceived task difficulty (*Pd*). In this instance, a task that is perceived to be difficult has tendency to weaken personal desire and motivation but enhanced self-efficacy and experience strengthened it (Carmona, Buunk, Dijkstra, & Peiro, 2008; Kellett, Humphrey, & Sleeth, 2009).

The strength and the value of the goal (*Gp*) that one set to achieve contribute to persistence (*Sp*) on the task. Also, cognitive engagement on the task (*Se*) and feed back from long term self-efficacy contributes to persistence (Schunk & Pajares, 2009). Figure 4.4 shows the causal relationship of the above while the formalization is shown in Equations 4.7 to 4.9.

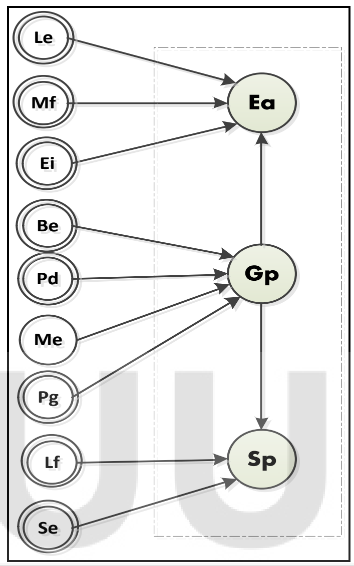

Figure 4.4. Efficacy Appraisal, Goal and Persistence

Formalization

The impact on efficacy appraisal (*Ea*) is derived by the aggregate contributions of Long-term efficacy (*Le*), personal goal (*Gp*), mental effort (*Mf*) and basic efficacy (*Be*). Personal goal (*Gp*) is formulated by the interplays of mastery experience (*Me*) basic efficacy (*Be*), and perceived task difficulty (*Pd*). However, the level of progress made towards goal (Pg) regulates personal goal (Pg). Short-term persistence (*Sp*) is formed through the proportional contributions of personal goal (Pg), short-term cognitive engagement (*Se*), and long-term efficacy (*Lf*).

$$Ea(t) = \alpha_{ea}.\left(\omega_{ea1}.Ei(t) + (1-\omega_{ea1}).Gp(t)\right) + (1-\alpha_{ea}).\begin{pmatrix} \omega_{ea2}.Le(t) + \\ (1-\omega_{ea2}).Mf(t) \end{pmatrix} \quad (4.7)$$

$$Gp(t) = \varphi_{gp}\left(\left(\rho_{gp}.\mathrm{Be}(t) + \left(1-\rho_{gp}\right).Me(t)\right).\left(1-Pd(t)\right)\right) + \left(1-\varphi_{gp}\right).Pg(t) \quad (4.8)$$

$$Sp(t) = \omega_{sp1}.Se(t) + \omega_{sp2}.Gp(t) + \omega_{sp3.}.Lf(t) \quad (4.9)$$

Short-term Cognitive Engagement (*Se*), Mental Effort (*Mf*) and Generated Effort (*Gf*).

The mental engagement of the interviewee during the task can be defined by the mental effort (*Mf*) which is influenced by efforts generated during the course of the task (Chow et al., 2015). This generated efforts is majorly contributed by the feedback from short-term efficacy. Primarily, short-term cognitive engagement (*Se*) is the aggregated summation proportions of basic efficacy (Be), skill (*Sk*), progress toward goal (*Pg*) and generated effort (*Gf*). Mental effort is generated through the combination of goal (*Gp*), basic efficacy (*Be*) and generated efforts (*Gf*). In this model, efforts are generated from the positive combination of mental effort (*Mf*) and short-term self-efficacy belief (*Sf*) (Schunk, 1991).

Figure 4.5 depicts the causal relations of the mental engagement entity and formalized in Equations 4.10 through 4.12.

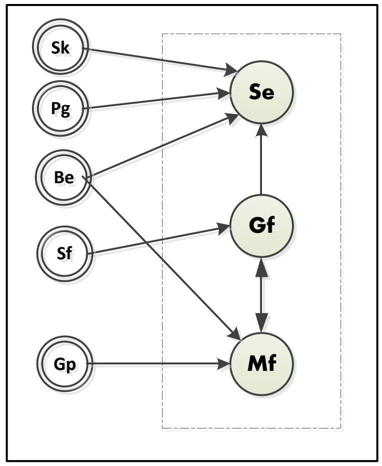

Figure 4.5. Mental engagement

Formalization

Short-term cognitive engagement (*Se*) is causally influenced by the contribution of generated effort (*Gf*), skill (*Sk*), progress towards goal (*Pg*) and basic efficacy (*Be*). Thecombined proportional contributions of generated effort (*Gf*), basic efficacy (*Be*) and personal goal (*Gp*) defines the strength of the Mental Effort (*Mf*). The disparities of mental effort (Mf) and short-term efficacy (*Sf*) define the values of generated effort (*Gf*) for a task.

$$Se(t) = \beta_{se}.\left(\omega_{se1}.Be(t) + (1-\omega_{se1}).SK(t)\right) + (1-\beta_{se}).\begin{pmatrix}\omega_{se2}.Pg(t) + \\ (1-\omega_{se3}).Gf(t)\end{pmatrix} \qquad (4.10)$$

$$Mf(t) = \gamma_{mf}.\left(\psi_{mf}.Gp(t) + \left(1-\psi_{mf}\right).Gf(t)\right) + \left(1-\gamma_{mf}\right).Be(t) \qquad (4.11)$$

$$Gf(t) = \omega_{gf}.\mathrm{Mf}(t) + \left(1-\omega_{gf}\right).Sf(t) \qquad (4.12)$$

Progress Towards Goal *(Pg)* and Short-term Efficacy (*Sf*)

Progress towards goal (*Pg*) is casually impacted by positive values of efficacy (*Sf*), long-term persistence (*Lp*) and mental effort (*Mf*). The proportions of contribution are estimated with weight influence of each of the causal factors (Seo et al., 2004). Self-efficacy at short term (*Sf*) is casually impacted by aggregation of goal (*Pg*), efficacy appraisal (Ea), and persistence (*Lp*) with basic efficacy (*Be*) all positive (Barrows et al., 2013). The entity depicting the relationship of progress on goal and short-term efficacy to causal inputs is shown in Figure 4.6 and formalized in Equations 4.13 and 4.14.

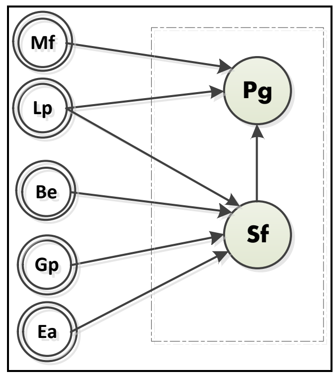

Figure 4.6. Progress on goals and Self-Efficacy

Formalization

The positive contributions of *Sf, Lp*, and *Mf* causally influence progress towards goal (*Pg*) and likewise, Short-term efficacy (*Sf*) is described through the proportional contributions of long-term persistence (*Lp*), efficacy appraisal (*Ea*), personal goal (*Gp*), with an influential contribution of basic efficacy (*Be*).

$$Pg(t) = \omega_{pg1}.\mathrm{Sf}(t) + \omega_{pg2}.Lp(t) + \omega_{pg3}.Mf(t) \tag{4.13}$$

$$Sf(t) = \lambda_{sf}.\left(\omega_{sf1}.Gp(t) + \omega_{sf2}.Ea(t) + \omega_{sf3.}.Lp(t)\right) + \left(1 - \lambda_{sf}\right).Be(t) \tag{4.14}$$

4.3.1.3 Conceptual Model of Self-efficacy

In conceptualizing self-efficacy model, various causal relationships between the pre-defined factors are identified and represented symbolically. Factors are represented as nodes while relationships are defined using arrows. The model consists of 8 exogenous factors, 13 internal state factors and 3 temporal factors. The entities of the models separately presented in Figures 4.2 to 4.6 are logically combined to obtain the conceptual agent model of self-efficacy in Figure 4.7.

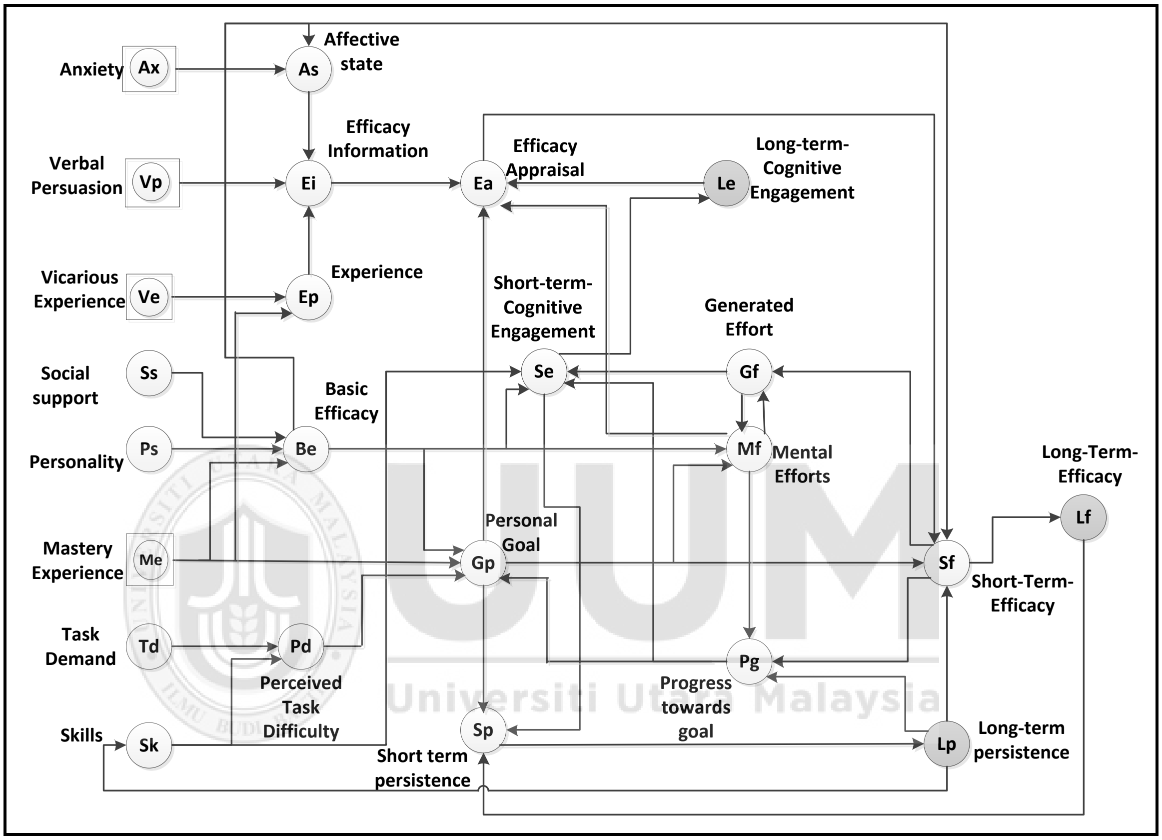

Figure 4.7. The conceptual Agent Model of Self-Efficacy Construct

The model depicted in Figure 4.7 shows the Self-efficacy conceptual model built from factors relating to human environment and experience, and the influence on the formulation of goal which fuels efforts through motivation. In addition, the efficacy states and dynamics are appraised by sourcing information from vicarious, persuasion, anxiety and mastery performance. Moreover, concepts in appraisal, persistence, and goal with basic efficacy to produce the short-term efficacy, which later forms a long-term efficacy level are logically connected.

4.3.1.4 Formalizing the Agent Model of Self-efficacy

To formalize the model, a set of differential equations meant for instantaneous elements of the model are derived at entity level above (i.e. Equations 4.1 to 4.14). However, the equations for the 3 temporal relations (Long-term engagement, Long-term persistence and Long-term efficacy) are derived in Equations 4.15 to 4.17 below. Both the instantaneous and temporal equations are derived according to the procedure defined in the previous Chapter (Section 3.5.4) of this Thesis.

Long-term cognitive engagement (*Le*) is obtained principally from accumulated experience of short-term cognitive engagement (*Se*). In the same vein, the accumulated exposure to short-term persistence (*Sp*) invariably produces long-term persistence (*Lp*) and the formation of long-term efficacy (*Le*) is modelled using the collected manifestation of short-term efficacy (*Sf*).

$$Le(t+\Delta t) = Le(t) + \beta_{le}.\left(\mathrm{Se}(t) - Le(t)\right).\left(1 - Le(t)\right).Le(t).\Delta t \tag{4.15}$$

$$Lp(t+\Delta t) = Lp(t) + \alpha_{lp}.\left(\mathrm{Sp}(t) - Lp(t)\right).\left(1 - Lp(t)\right).Lp(t).\Delta t \tag{4.16}$$

$$Lf(t+\Delta t) = Lf(t) + \gamma_{lf}.\left(\mathrm{Sf}(t) - Lf(t)\right).\left(1 - Lf(t)\right).Lf(t).\Delta t \tag{4.17}$$

4.3.2 Interview Motivation Agent Model

Theories and concepts related to motivation to participating and performing in interview related domains are identified in this section. Later these factors are causally represented into constituent entities and formalized (Figure 4.8 to 4.10 and Equation 4.18 to 4.32).

The conceptual model of interview motivation is presented (Figure 4.11) and the formalization of the dynamics of the temporal states in the model (Equation 4.33 to 4.34) concludes this section.

4.3.2.1 Factors in Interview Motivation

Generally, motivation represents drive, desire or will to act or to do something (goal). Once a goal is set, the motivation will direct and intensify efforts (both consciously or unconsciously) towards achieving such intended goals (Schunk, Meece, & Pintrich, 2012). The main idea of motivation is a unified concept of two main theories in affective and cognitive perspectives (De Brabander & Martens, 2014). First, the affective theories emphasize emotion related experiences of an activity such as internal desires (e.g. self-determination and flow theories)., Second, the cognitive theories provide a rational reflection towards the consequences of an activity (e.g. expectancy-value theory) (Locke, 2000). Thus, these theoretical models represent motivation as a causal factor for actions generated from the interplay of valence expectation (*incentives*) and feasibility expectation (*outcome expectation*). A valence expectation is the outcome of the interaction between affective and the cognitive valences of the intended action. For example, the envisage valence expectation is a result of an intricate interplay between affective, cognitive, positive and negative motivators.

In this case, the affective valence is reciprocally affected by a perceived personal autonomy which is built from a sense of freedom to take action. Feasibility expectation, on the other hand, stemmed from beliefs of competency and sense of external supports (De Brabander & Martens, 2014). The constructs of human autonomy, competence and psychological relatedness as basic human needs that inherently drive motivation has been postulated in self-determination theory(Jang, Kim, & Reeve, 2016; Jeno, Adachi, Grytnes, Vandvik, & Deci, 2018). Autonomy is the absence of external forces and the opportunity to be self-responsible, competence reflects the experience to undertake activities that are within the reach of personal capacity, and relatedness is the feeling of connectedness to fellow human-beings within the activity context (Deci & Ryan, 2012). The result of the influence of personal competence to activity challenge is further explained by flow theory. The interaction between competence and activity challenge can results into 1) *boredom* (competence is higher than the task challenge), 2) *apathy* (low competence in a low challenge task), 3) *flow* (high competence in a challenging task), and 4) *anxiety* (low competence faced with a challenging activity) (Deci & Ryan, 2012).

Furthermore, according to the ―Expectancy-Value theory", the motivation of a person to an event is determined by the expected success and values to the goals. (Hulleman, Barron, Kosovich, & Lazowski, 2016; Wigfield & Eccles, 2000). The Expectancy Theory explores how rewards affect motivation and performing a task. Likewise, value refers to perception towards the outcome of completing the task. This model also provides crucial constructs for self-efficacy, ability, beliefs, and goal orientation. These beliefs later influence the goal orientation (e.g. desirability about tasks end result) and values associated to reward (Locke & Latham, 2002). In addition, those with a strong goal orientation level will deploy their current resources and skills to evaluate the effects of reaching and fulfil that particular goal (Schunk et al., 2012; Yee & Braver, 2018).

Table 4.3 summarizes the important concepts of motivation in interviewing process.

Table 4.3

Identified Interview Motivation Factors

	SN	Concept	Notation	Description	Reference
Input Factors	1	Perceived Autonomy	*Pa*	Freedom of action	(Deci & Ryan, 2012)
	2	Perceived Relatedness	*Rd*	The feel of connectedness with the interviewer	(Deci & Ryan, 2012)
	3	Social Support	*Ss*	Support from close associates	(Schunk, 1995; Wang et al., 2015)
	4	Task Demand	*Td*	A need to be resolved by a specific working effort	(Fonseca et al., 2014)
	5	Prior Experience	*Ep*	Positive engagements in interview or related task	(Nakamura & Csikszentmihalyi, 2014; Wigfield & Eccles, 2000)
	6	Cognitive Engagement	*Ce*	Psychological investment in and effort directed towards solving task at hand	(Board, 2016)
	7	Self-Efficacy *	*Sf*	Belief in one's ability to engage in course of action necessary to solve a specific task	(Barrows et al., 2013; LeRouge et al., 2016)
Internal factors	8	Situation Demand	*Sd*	Perceived interview situation complexity in relation to difficulty and relatedness	(Fonseca et al., 2014)
	9	Coping Resources	*Cr*	Human resources needed to meet the situation demand	(Fonseca et al., 2014)
	10	Perceived Task Difficulty	*Pd*	Task complexity	(Eysenck & Calvo, 1992; Naismith, Cheung, Ringsted, & Cavalcanti, 2015)
	11	Interview skills	*Sk*	This is the know-how developed from knowledge and practice of interview	(Hayes et al., 2015)
	12	Task-Specific Threat	*Th*	Evaluation of lesser resources to cope with situation demand of a task	(Fonseca et al., 2014)
	13	Goal Orientation	*Gl*	Understanding about the broad desire	(Schunk et al., 2012)
	14	Perceived Competence	*Pc*	Perception of one's ability	(Deci & Ryan, 2012)
	15	Performance Expectancy	*Pe*	Expected success	(Wigfield & Eccles, 2000)
	16	Affective Valence	*Av*	Value associated with emotions for success	(Deci & Ryan, 2012)
	17	Cognitive Valence	*Cv*	Value associated with cognition for success	(Deci & Ryan, 2012)
	18	Expectancy-Value	*Ev*	The value associated with success	(Wigfield & Eccles, 2000)
	19	Persistence (Short-term and Long-term)	*Sp & Lp*	Personal commitment or perseverance on task	(Schunk & Pajares, 2009)
	20	Motivation (Short-term and Long-term)	*Sm & Lm*	Drive, desire or will to participate in the Interview session and perform well	(Dipboye, 2017; Tross & Maurer, 2008)

4.3.2.2 Entities of Motivation Agent Model

The entity relationships that networked to the conceptual model of interview motivation agent model are defined in Figures 4.8 to 4.12 below. Each of the presented entity is formalized with sets of equations that follow.

Skill *(Sk)* on Situation Demand *(Sd),* Coping Resources *(Cr)*, and Perceived Task Difficulty *(Pd)*

The combination of perceived task difficulty (*Pd*) and relatedness (*Rd*) generated the situation demand (*Sd*). A high positive disposition from the interviewer reduces potential stress onset that later undermines possible situation demand and vice versa for the perceived task difficulty (Fonseca et al., 2014). Coping resources (*Cr*) is an internal state that is regulated by the combination of personal autonomy (*Pa*), social support (*Ss*), previous experience in interview or selection task (*Pe*) and self-efficacy (*Lf*). Personal autonomy is the perceived freedom of choice in the task which is capable of boosting motivation by strengthening the coping resources to withstand stressors (Deci & Ryan, 2012). The (*Pa*) therefore is influenced by the experienced emotion (*Av*) during the task execution (Naismith et al., 2015).

In this study, perceived task difficulty (*Pd*) is defined by the aggregated values from task demand (*Td*), prior experience (*Pe*), and skill (*Sk*) (Eysenck & Calvo, 1992). Both of experience and skills reduce perceived task difficulty, while task demand amplified the risk. Basic skill inherent in the interviewee can be enhanced by previous interview experience (*Pe*) as well as the long-term persistence (*Lp*) to doing well at the interview. Greater level of skills is developed as people, through previous experience, master challenges in an activity (Nakamura & Csikszentmihalyi, 2014). The aggregation for both experience (*Pe*) and long-term persistence (*Lp*) is regulated proportionally by the basic skill (SK_{norm}). The relationship of the 4 constructs and the exogenous factors are depicted in Figure 4.8. The formalization is presented in Equations 4.18 to 4.21.

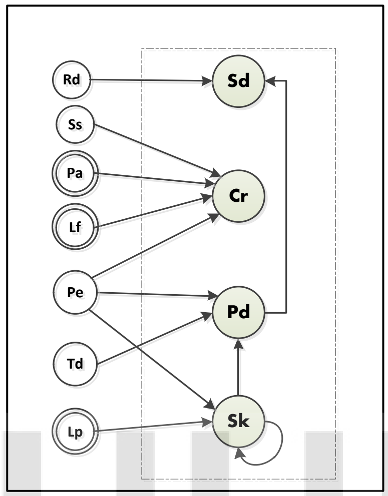

Figure 4.8. Causal relations of skills, perceived task difficulty, coping resources and situation demand

Formalization

Perceived autonomy (*Pa*) can be conceptually defined as the interviewee's sense of freedom in the interview environment. This concept can be further elaborated through the interaction of an intrinsic motivation on the task defines by affective valence (*Av*). Situation demand, on the other hand, is causally formulated from a sense of relatedness with the interviewer defined by perceived relatedness (*Rd*) and negativity in perceived task difficulty (*Pd*). Self-efficacy (Lf) is a composite construct that influences motivation through persistence and as a coping resource. It is influenced by one's motivational level. Perceived task difficulty (*Pd*) is a construct that greatly influences personality beliefs which define desires and motivation during an interview session. It affects goals, expectancy, and values (Schunk et al., 2012). Thus, this concept can be perceived as the proportional impact on task demand (*Td*) and negative proportion from an aggregated impact level of interpreted experience and interview skills. Skill (*Sk*) is developed through the causal impact of personal interview experience (*Pe*) and persistence over time (*Lp*) (Schunk et al., 2012).

$$Pa(t) = Pa(t) * Av(t) + \left((1 - \alpha_{pa}). Av(t)\right) \tag{4.18}$$

$$Sd(t) = Pd(t) * \left(1 - Rd(t)\right) \tag{4.19}$$

$$Lf(t) = Lf(t) * Lm(t) \tag{4.20}$$

$$Cr(t) = \omega_{cr1}. Pe(t) + \omega_{cr2}. Ss(t) + \omega_{cr3}. Lf(t) + \omega_{cr4}. Pa(t) \tag{4.21}$$

$$Pd(t) = Td(t). \left(1 - \left(\omega_{pd1}. Pe(t) + \omega_{pd2}. Sk(t)\right)\right) \tag{4.22}$$

$$Sk(t) = \gamma_{sk}. Sk_{norm} + (1 - \gamma_{sk}) . \left(\omega_{sk}. Pe(t) + (1 - \omega_{sk}). Lp(t)\right) \tag{4.23}$$

Task-Specific Threat *(Th)*, Goal (*Gl*), Perceived Competence (*Pc*) and Persistence (*Sp*)

During test taking situation such as interviewing process, interviewees generally get threatened as a result of the imbalance between situation demand (*Sd*) and the internal resources to cope with the situation (*Cr*). Thus, when coping resources are inadequate to cope with the situation demand, then the individual generally tend to feel threatened (Fonseca et al., 2014). Therefore, the threat level is positively correlated to the situation demand but reduced by coping resources. Motivation during task is initiated by the perception on competence (*Pc*) engaging in the task. Perceived competence (*Pc*) has been identified in literature to correlates to the expectancy or probability of success (Weiner, 2013). It refers to the extent of one can estimate their capability to complete a task. Normally, it also related to the self-efficacy belief (*Se*) and personal interview skills

(Nakamura & Csikszentmihalyi, 2014). Goal orientation (*Gl*) is the degree to which interviewee is focused on his/her desire and is central to the internal states for building task motivation. The impact on goal is contributed by interplays between personal competence and perceived difficulty. However, task-related threat (*Th*) is capable to distract the interviewees from their target goal (Deci & Ryan, 2012; Jeffrey B. Vancouver & Purl, 2017). Consequently, the goal regulates the value of persistence (*Sp*) on task which is determined largely by the proportional contributions of previous experience (*Pe*), and feedbacks arising from self-efficacy (*Lf*) and motivation (*Sm*) (Nakamura & Csikszentmihalyi, 2014).

The causal relation of the motivation building states of threats, goal, perceived competence and persistence is depicted in Figure 4.9 and formalized in Equations 4.24 to 4.27.

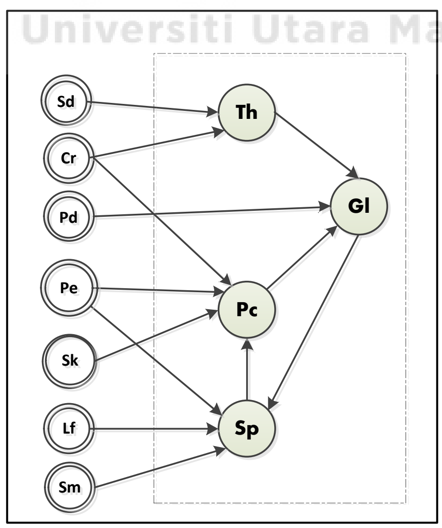

Figure 4.9. Motivation building states block

Formalization

Threat (*Th*) is the difference in situation demand (*Sd*) and coping resources (*Cr*) of the interviewee. Perceived competence (*Pc*) is built from the available resources (*Cr*) to withstand threats (*Th*), prior experience (*Pe*) and skills (*Sk*). Personal goal (*Gl*) is positively influenced by the aggregation of perceived competence (*Pc*) and perceived task difficulty (*Pd*) and negatively affected by Task-specific threat (*Th*). Short-term persistence is developed from the aggregation of short-term motivation (*Sm*) and self-efficacy (*Lf*) and regulated by goals (*Gl*).

$$Th(t) = Sd(t).(1 - Cr(t)) \tag{4.24}$$

$$Pc(t) = \omega_{pc1}.Cr(t) + \omega_{pc2} * Sk(t) + \omega_{pc3} * Pe(t) \tag{4.25}$$

$$Gl(t) = \left(Pc(t) + Pd(t)\right).\left(1 - Tt(t)\right) \tag{4.26}$$

$$Sp(t) = \left(\varphi_{sp}.\mathrm{Lf}(t) + \left(1 - \varphi_{sp}\right).Ms(t)\right).\ Gl(t) \tag{4.27}$$

Expectancy –Value Motivation States (*Va, Vc, Ve, Ep, Sm*)

Motivation (*Sm*) has been modelled as the function of performance expectation (*Ep*) and expectation value (*Ve*) (Wigfield & Eccles, 2000). Performance expectation (*Ep*) is the degree to which an individual believes he or she will perform well in a task given the current experienced situation (Calderón, López, & Peña, 2017). This process is directed to the self-efficacy and ability belief constructs. Moreover, it is related to personal competence belief and perceived external social factors that define coping resources (Cr) (De Brabander & Martens, 2014). Goal orientation and subjective value of the task (*Ve*) also provide a positive contribution to the construct (Wigfield & Eccles, 2000). Expectancy value (*Ve*) on the other hand is the value associated with the result obtained from performance in the task (Hulleman et al., 2016). In this study therefore, high performance expectancy improves affective valence (*Va*) while task-specific threat (*th*) reduces the effect. Affective valence (*Av*) defines the internal feelings of interviewee during the task. It emphasizes the affective experience of activity like having interest and pleasure while performing given tasks (intrinsic motivation).

Cognitive valence is affected by the proportional aggregation of perceived task difficulty and sum of goal and expectation influenced by long-term persistence (De Brabander & Martens, 2014; Wigfield & Eccles, 2000). Value expectation (*Ve*) is the value associated with successful task behavioural or task performance (De Brabander & Martens, 2014). Short term motivation (*Sm*) provides a task-specific motivation which is the readiness to take specific action relatively available to a person (De Brabander & Martens, 2014). As in most motivation theories, it functions as an expectation for success (expectancy) and utility or resourcefulness of the outcome of such success (value). This concept can be translated to the development of persistence when aggregated with self-efficacy in a regulated fashion. The interplay between the states are depicted in Figure 4.10 and formalized in Equations 4.28 to 4.32 below.

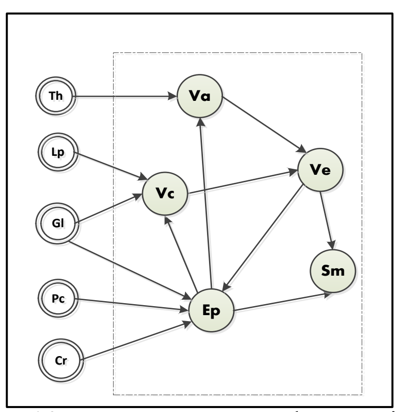

Figure 4.10. Expectancy – Value motivation states

Formalization

The interviewing process relates the performance expectancy (*Ep*) by proportional contributions of perceived competence (*Pc*), coping resources (*Cr*), goal orientation (*Gl*) and value associated to the expectancy (*Ve*). Performance expectancy (*Ep*) is regulated negatively by task-specific threat (*Th*) to casually define affective valence (*Va*). Cognitive valence (*Vc*) is a thought process leading to the subjective value associated with a task, while cognitive theories stress rational reflection concerning to the consequence of activity (extrinsic motivation). Perceived task difficulty (*Pd*) refers to the value associated with a task. Regulated summation of goal and expectancy with persistence can be aggregated to task difficulty component, as defined to the subjective task value. Value expectation (*Ve*) is subjective task value impacted by high or low combinations of affective (positive) and cognitive (positive) valence.

$$Ep(t) = \alpha_{ep}.\big(\omega_{ep}.Pc(t) + (1-\omega_{ep}).Cr(t)\big) + (1-\alpha_{ep}).\begin{pmatrix} \omega_{ep1}.Gl(t) + \\ (1-\omega_{ep1}).Ve(t) \end{pmatrix} \quad (4.28)$$

$$Va(t) = Ep(t).\big(1 - Tt(t)\big) \quad (4.29)$$

$$Vc(t) = \alpha_{cv}.Pd(t) + (1-\alpha_{cv}).\big(Gl(t) + Ep(t)\big).Lp(t) \quad (4.30)$$

$$Ve(t) = \lambda_{ve}.Av(t) + (1-\lambda_{ve}).Cv(t) \quad (4.31)$$

$$Sm(t) = \psi_{ms}.Ve(t) + (1-\psi_{ms}).Ep(t) \quad (4.32)$$

4.3.2.3 Conceptual Agent Model of Motivation

The entity relations defined on Figures 4.8 to 4.10 presented 4 external factors and 16 states (internal) factors. These factors are functionally networked with attendant temporal factors to create the conceptual agent model of motivation shown in Figure 4.11. External (input variables) are the extreme left nodes, however, input nodes in square are state factors from other models. The nodes in grey colours represent temporal states.

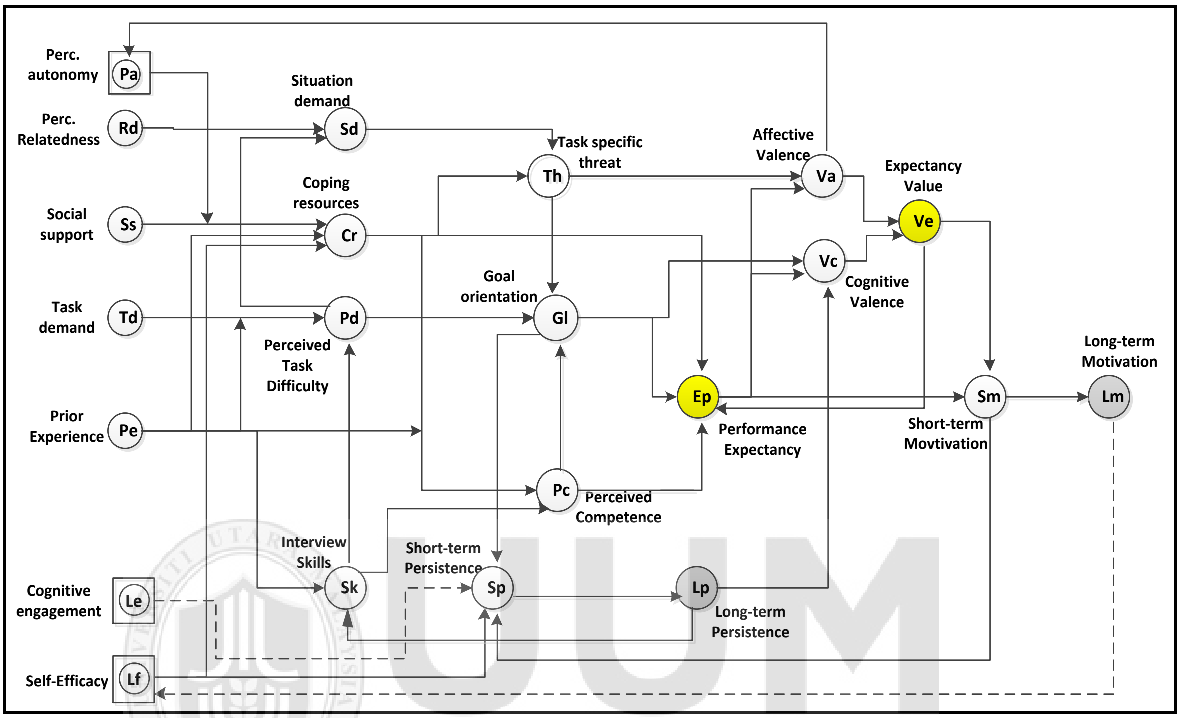

Figure 4.11. Conceptual agent model of motivation construct

Figure 4.11 is the conceptual agent model of interview motivation based on concepts and theories relating to task-specific motivation as explained in Section 4.3.2.1. This model contains 13 instantaneous factors that have already been formalized in Equations 4.18 to 4.32. The 2 temporal relations are therefore formalized accordingly in the following section.

4.3.2.4 Formalizing the Dynamics of Model of Motivation Agent

The temporal representation of interview motivation agent model is defined in Equations 4.33 to 4.34. Long-term motivation (*Lm*) is the accumulation exposure of short-term motivation (*Sm*) over time. λ_{ml} relates the decay function to represent possible degradation in motivation (Gnambs & Hanfstingl, 2016). The formation of long-term persistence (*Lp*) is modelled from the accumulated presence of short-term persistence level (*Sp*).

$$Lm(t + \Delta t) = Lm(t) + \beta_{lm}.\begin{bmatrix} Pos\big(Sm(t) - Lm(t)\big).\big(1 - Lm(t)\big) \\ -Pos\big(-(Sm(t) - Lm(t) - \lambda_{ml})\big).Lm(t) \end{bmatrix}.\Delta t \qquad (4.33)$$

$$Lp(t + \Delta t) = Lp(t) + \alpha_{lp}.\big[\big(Sp(t) - Lp(t)\big).Lp(t).\big(1 - Lp(t)\big)\big].\Delta t \qquad (4.34)$$

4.3.3 Interview Anxiety Agent Model

This section builds the interview anxiety agent model. The first sub-section identifies the factors for the interview anxiety domain model from theories, concepts and related models. This is followed by a sub-section for designing the functional entities of the design model (Figures 4.12 to 4.16) and formalising with mathematical equations (Equation 4.35 to 4.38). The third sub-section presents the conceptual model of interview anxiety as depicted in Figure 4.17 and finally the formalization of the dynamics of the temporal states in the model (Equation 4.39 to 4.40) is the last sub-section.

4.3.3.1 Factors in Interview Anxiety

A prospective interviewee is most affected by the pervasive problem of stress, as the competitive and evaluative nature of the selection process is capable to evoke feelings of frustration and distress (Rynes, Bretz, & Gerhart, 1991). As an interview process involves social dialogues with unknown personality (interviewer) and talking with strangers in a situation, this condition will induce potential anxiety cases among people with low control triggers anxiety (Ayres et al., 1998). Modelling interview anxiety involves the consideration of concepts from theories of test-taking anxiety and model of generalized anxiety whose constructs is centred on generated threat that translated into worries. This later can take attention away from the actual test (interview).

The process to experience anxiety is a complex one that can be defined in the dimensions of behavioural, cognitive, emotional or physical symptoms (Matthew, Melanie , Sony, & Fugen, 2017). While trait refers to the individual vulnerability towards anxiety based on personality, the state is the reaction to the threatening situations that can develop tension and physiological responses (e.g. increased heart rate), such as job interview (Feiler & Powell, 2015). However, state anxiety is generally short-lived as it's a reaction to immediate threat during situation that amplified by trait (Eysenck & Calvo, 1992). A number of studies have described how anxiety inhibits performance especially on tasks with high attention or short-term memory demands (Barrows et al., 2013; Feiler & Powell, 2015). Later, prolonged anxiety impairs performance through worry about the threat that forces individuals to engage in passive coping strategies which invariably takes attention away from the main problem. This later will cause two main effects: (1) a decrease in the capacity of working memory required for storage and processing concurrent task; and (2) an increment in on-task effort and activities designed to improve performance (Eysenck & Calvo, 1992).

Theories of test-taking anxiety are relevant as selection interview is considered a type of test (McCarthy & Goffin, 2004). Anxiety can be grouped as performance anxiety (i.e. worry) or behavioural anxiety (i.e. emotion). Performance anxiety is related to the worry about the test outcomes (e.g. fear of failure). On the other spectrum, behavioural anxiety reflects as an experienced autonomic arousal conceptualized (e.g. bodily tension during test taking event) (Spielberger & Vagg, 1995). The development of a conceptual model of interview anxiety, the causal factors of Type 1 Worry are related to the assertiveness and trait factors that inhibit thought process during the interviewing process. In this case, the negative emotion generated from the worry formation construct caused the negative belief about worry and danger visualization (self-appraisal) that later could be perceived as threat, either before or during interview session (Ryum et al., 2017).

From cognitive psychology perspective, worry refers to “primarily an anticipatory cognitive process involving repetitive, primarily verbal thoughts related to possible threatening outcomes and their potential consequences” (Tallis, Eysenck, & Mathews, 1991). The worrying process begins when an individual must perceive the prospect of a potential threat that triggers worry (Borkovec et al., 2004). Hence, the greater the perceived threat, the greater is the severity of the worry (Fonseca et al., 2014). In this study, major assumption is related to the activation of threat and the subsequent biological, emotional, behavioural and cognitive responses are resulted from relative evaluations of coping resources (e.g., social support, autonomy, competence beliefs, skills, previous knowledge) and task demands (e.g., required effort, danger, task difficulty, uncertainty, perceived relatedness). From this perspective, threat is experienced when an individual is implicitly or explicitly evaluate fewer resources to cope with situation demand for a task (Fonseca et al., 2014; Ryum et al., 2017)

This particular concept explains that thinking of uncertain future event, such as in interview that involves a social interaction with unfamiliar personality, can make vulnerable individuals interpret and direct their attention to potential negative outcomes (Hirsch & Mathews, 2012). In this case, high level of anxiety and worry were characterized by selective attention to threatening signs corresponded to emotions (e.g. body sensations, mental images or worrying thoughts (Hayes et al., 2010). Moreover, personality factor and traits play important roles in defining the sensitivity of an individual which affect the interpretation and adaptive tendencies based on unpredicted social events (e.g. selection interview) (Hirsch & Mathews, 2012). Assertiveness is another important component to foster self-belief. The non-assertive person normally experienced an "internal dialogue of conflict" that can be very disruptive when they do occur in interviews (Heimberg & Keller, 1986).

Summarily, the relationship that can be identified from the above is that anxiety during interview situation can be caused by series of psychological and physiological stressor factors (Soeter & Kindt, 2015). Leading to anxiety is worry on a long term which manifests due to low coping resources to withstand perceived threat (Ellis & Hudson, 2010; Gong, Wen, Dajun, & Delef, 2016; Hirsch & Mathews, 2012). Coping resources is an internal factor that is developed by strength of belief in ability (Self-efficacy), experience in similar task and social supports (Levy, Nicholls, & Polman, 2011; Wells, 1999). However, good coping resources and low situation demand reduce perceived threats (Tan-Kristanto & Kiropoulos, 2015). High trait anxiety with negative personality influences belief about worry through sensitivity which also has negative effect on appraisal (Wells, 1999). Belief about worry influences more resources to be channelled to cope with the worry hence more worry, and prolonged short-term worry will increase the risk of long-term worry in the future (Barrows et al., 2013).

The relevant factors relating to interview anxiety model are described in Table 4.3 below.

Table 4.3

Identified Interview Anxiety Factors

	SN	Concept	Notation	Description	Reference
Input Factors	1	Perceived Relatedness	*Rd*	The feel of connectedness with the interviewer	(Fonseca et al., 2014)
	2	Perceived Task Difficulty	*Pd*	Task complexity	(Fonseca et al., 2014)
	3	Self-Efficacy	*Sf*	Belief in one's ability to engage in course of action necessary to solve a specific task	(Barrows et al., 2013)
	4	Prior Experience	*Pe*	Positive engagements in interview or related task	(Ekambareshwar et al., 2018; Fonseca et al., 2014)
	5	Personal Autonomy	*Pa*	Freedom of action	(Fonseca et al., 2014)
	6	Social Support	*Ss*	Support from close associates	(Schunk, 1995)
	7	Trait (anxiety)	*Tr*	Inherent feel of apprehension	(Feiler & Powell, 2015)
	8	Personality (assertiveness)	*Pn*	Quality of being self-assured and confident without being aggressive	(Lounsbury et al., 2003)
Internal factors	8	Situation Demand	*Sd*	Perceived interview situation complexity in relation to difficulty and relatedness	(Bakker & Demerouti, 2017)
	9	Perceived Threat	*Th*	Evaluation of lesser resources to cope with situation demand of a task	(Fonseca et al., 2014)
	10	Coping Resources	*Cr*	Human resources needed to meet the situation demand	(Fonseca et al., 2014)
	11	Sensitivity	*Sy*	Degree of awareness and responsiveness to internal and external changes, challenges, or demands	(MacDorman & Entezari, 2015)
	12	Belief about Worry	*Bw*	Categorizing worry as a coping strategy in a threatening situation	(Barrows et al., 2013; Ryum et al., 2017)
	13	Experience worry (Short-term and Long-term)	*Sw and Lw*	The state of being anxious and troubled	(Gong et al., 2016; Ryum et al., 2017)
	14	Appraisal	*Ap*	Evaluation of one's reaction to worry	(Wells, 1999)
	15	Thought control	*Tc*	Ability to manage thought in a threatening situation	(Ryum et al., 2017)

4.3.3.2 Entities of Anxiety Agent Model

The entities that make up the agent model of anxiety are described in causal relationship diagrams in Figures 4.12 to 4.13 below. The set of equations that follows formalize the functional components of the design.

Functional Relationship of Threat and Sensitivity states to Coping resources and Situation demand

Feeling of threat is the foundation of worry in evaluating task situation such as in interview. The interviewee feel worried when they feel they has less internal resources such as the skills, experience or knowledge to withstand the prevailing situation demand. Therefore, threat ensues when there are inadequate resources (*Cr*) to cope with the situation demand (*Sd*) (Fonseca et al., 2014). Situation demands (*Sd*) are various environmental factors an interviewee have to manage with (Bakker & Demerouti, 2017). This is viewed in interview situation from the perceived task difficulty (*Pd*) and perceived relatedness (*Rd*). First, the perceived task difficulty is a compound factor that increases situation demand but the effect of perceived relatedness (i.e. from the interviewer disposition) reduces the formation of situation demand state. Coping resources on the other hand is a state defined from the interactions of external social environment and personal factors such as experience in similar task (Pe), social support (Ss), self-efficacy (Lf) and degree of the feel of freedom (personal autonomy) (Pa) (Fonseca et al., 2014). Sensitivity (*Sy*) is defined by the inherent trait (*Tr*) of an individual as well as his/her personality (*Pn*). Assertiveness is a personality feature that defines one's stability level. A high assertive personality is less sensitive to arousal or anxious moments (Feiler & Powell, 2015; Lounsbury et al., 2003). High sensitivity is related to genetic disposition (traits and personality) and decimated or stabilized by the level of coping resources (*Cr*) (MacDorman & Entezari, 2015).

The relationship among these key states and their inputs states are depicted Figure 4.12. The formalization is represented in Equations 4.35 to 4.38.

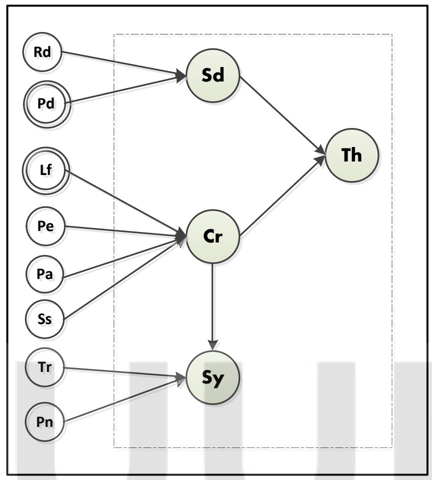

Figure 4.12. Functional relations of Threat and Sensitivity states to Coping resources and Situation demand

Formalization

Situation demand (*Sd*) is causally constituted in interview situation by perceived task difficulty (*Pd*) and interviewer disposition conceptualized as interviewee perceived relatedness (*Rd*). Coping resources (*Cr*) is conceptualized from available human resources to stand the uncertainties and perceived dangers during interview sessions. The higher the prior experience (*Pe*) at similar events and perceived social support (*Ss*), the higher the coping resources. Perceived competence, conceptualized as self-efficacy (*Se*) have a positive contribution just as perceived freedom of choice conceptualized as personal autonomy (*Pa*) impacted positively on available resources.

$$Sd(t) = Td(t).\big(1 - Rd(t)\big) \tag{4.35}$$

$$Cr(t) = \omega_{cr1}.Pe(t) + \omega_{cr2}.Ss(t) + \omega_{cr3}.Se(t) + \omega_{cr4}.Pa(t) \tag{4.36}$$

Task-specific threat (*Th*) is causally defined by the impact of situation demand (*Sd*) and depleted by the number of resources (*Cr*) to cope with the demand. The strength of detecting stimuli (*Sy*) during interview task can be defined by a perceived threat which is reduced by a regulated combination of assertive personality (*Pn*) and available resources to cope with the threat (*Cr*).

$$Th(t) = Sd(t).\big(1 - Cr(t)\big) \tag{4.37}$$

$$Sy(t) = Tr(t).\Big(1 - \big(\alpha_{sy}.\big(Pn(t)\big) + \big(1 - \alpha_{sy}\big).Cr(t)\big)\Big) \tag{4.38}$$

Anxiety Prospect from Worry States and Thought Control

The belief the interviewee has on worry (*Bw*) as a strategy for taking attention away from the interview threat is capable of manifesting into more worries and this further affect the control of thoughts. The lack of thought control (*Tc*) degrades the positive self-appraisal state and this can throw the interviewee off balance as anxiety builds (Hirsch & Mathews, 2012). Conversely, thought control can be improve by positive personal appraisal (*Ap*) as worry over time (anxiety) (*Lw*) reduces it

Short-term worry (*Sw*) manifests due the aggregated impact of the states of belief about worry (*Bw*), threat (*Th*), coping resources (*Cr*) and self-appraisal (*Ap*). These four constructs can be grouped into two parts, escallalting and de-escallating parts. The proportional aggregate of belief about worry and threat is related to the escalating part while coping resources and positive self-appraisal are related to the de-escalating part (Gong et al., 2016; Ryum et al., 2017).

The functional relationships are shown in Figure 4.13 and formalized in Equations 4.39 to 4.41.

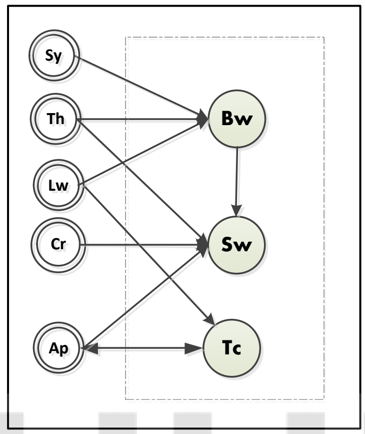

Figure 4.13. Functional Relations of anxiety from Worry States and Thought Control

Formalization

The effect of belief about worry (*Bw*) is dependent on low and high values from task-specific threat (*Th*), sensitivity (*Sy*) and long-term experienced worry (*Lw*). Short-term experienced worry (*Sw*) is positively impacted by the high level of threat (*Th*), belief about worry (*Bw*), low level of coping resources (*Cr*), and low level of positive appraisal (*Ap*). Thought control (*Tc*) is causally increased by positive self-evaluation (appraisal) whereas long-term experienced worry (*Lw*) decreases its effects.

$$Bw(t) = \gamma_{bw} . \left(\beta_{bw}. Th(t) + (1 - \beta_{bw}). Lw(t)\right) + (1 - \gamma_{bw}). Sy(t) \tag{4.39}$$

$$Sw(t) = \left(\varphi_{sw}. Bw(t) + (1 - \varphi_{sw}). Th(t)\right) * \left(1 - \left(\begin{matrix} \psi_{sw}. Cr(t) \\ +(1 - \psi_{sw}). Ap(t) \end{matrix}\right)\right) \tag{4.40}$$

$$Tc(t) = Ap(t). (1 - Lw(t)) \tag{4.41}$$

4.3.3.3 Conceptual Model of Interview Anxiety Agent

The structural relationships in the model have been determined from the concepts and theories identified in the literature relating to interviewee anxiety. The causal relationships at the entity level were shown in Figures 4.12 and 4.13. These entities are logically networked to make the proposed conceptual agent model of interview anxiety as shown in Figure 4.14.

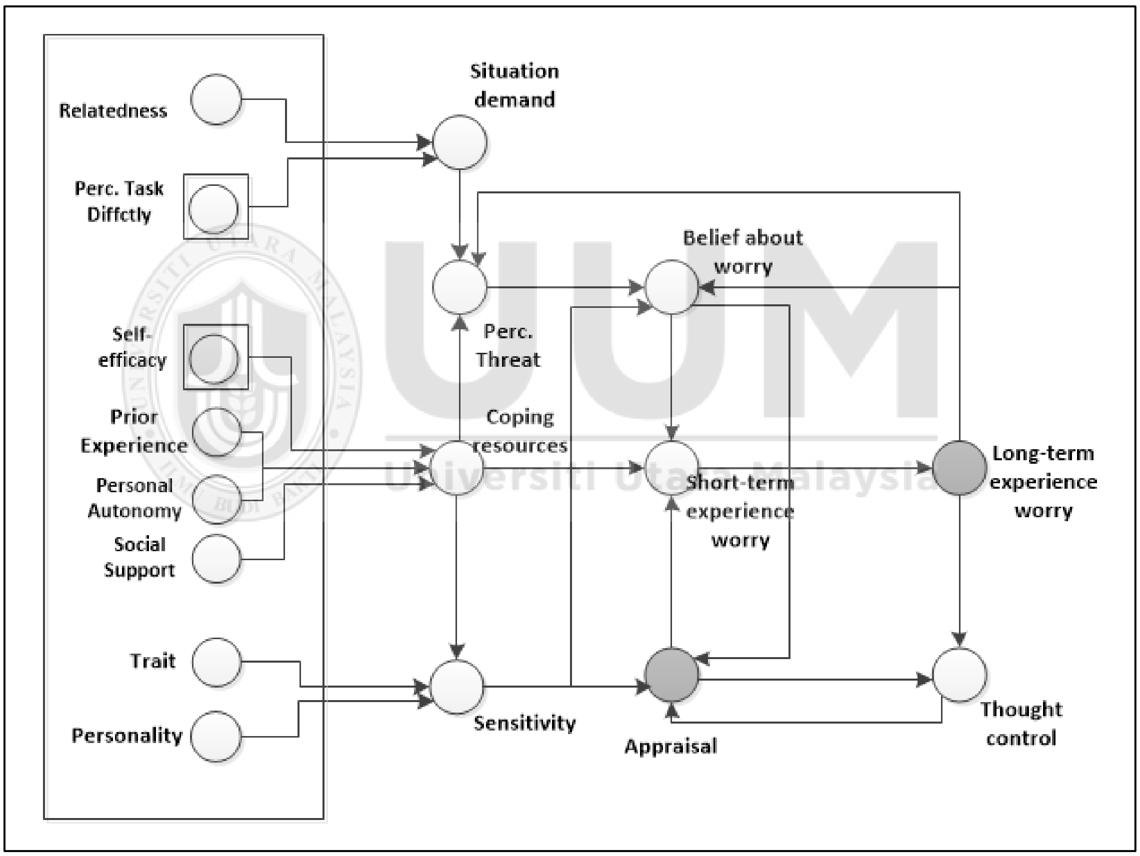

Figure 4.14. Conceptual agent model of interview anxiety

Figure 4.14 is the conceptual model for interviewee anxiety. It illustrates how various factors interplay in human agent confronted with interview situation and develops into some level of anxiety. The perception of threat that precipitates during events is initiated when the situation demand is higher than the available resource to cope with the demand. The level of threat is the difference in the value of the two constructs of situation demand and coping resources. In an interview situation, the situation demand is defined by the level of difficulty of the task and the perceived relatedness of the interviewer with the interviewee which can equally be defined as interviewer disposition. Self-efficacy, social support, personal autonomy and previous experience are key factors related to resources an interviewee needs in possession in order to withstand the pressure of the interview. Sensitivity is defined by personality (assertiveness), trait anxiety and coping resources. The belief one has on worry (belief about worry) as a coping skill to a threatening event further strengthen worry if sensitivity is high. Belief about worry equally makes the interviewee have negative appraisal about self and this further increases worry and reducing the ability to control thought (thought control). The unsettled worry over a few time results in anxiety (long time worry), which has sprinkling effect on thought control, belief about worry and perceived threat.

4.2.3.4 Formalizing the Dynamics of Interview Anxiety Agent Model

The instantaneous constructs were formalized at the entity design stage in Equations 4.35 to 4.41above. The two temporal states (Appraisal (*Ap*) and Long-term worry (*Lw*)) relations are therefore defined and presented in Equations 4.42 and 4.43 below.

Temporal Relationship

The formation of appraisal (*Ap*) is modelled using the contributions of belief about worry (*Bw*), coping resources (*Cs*), and thought control (*Tc*) that accumulate with time. Sensitivity plays a role in the way one evaluates him/herself. Meta-worry, which can contextually be defined as long-term experienced worry (*Lw*), is the accumulated exposure of short-term worry (*Sw*) over time.

$$Ap(t+\Delta\mathrm{t}) = Ap(t) + \beta_{ap}.\begin{bmatrix} Pos\big(Zx(t) - Ap(t)\big).\big(1 - Ap(t)\big) - \\ Pos\left(-\big(Zx(t) - Ap(t)\big)\right).Ap(t) \end{bmatrix}.\Delta\mathrm{t} \qquad (4.42)$$

Where

$$Zx(t) = \big(\omega_{zx}.Cr(t) + (1-\omega_{zx}).Tc(t)\big).\big(1 - Bw(t)\big).\big(1 - Sy(t)\big)$$

$$Lw(t+\Delta\mathrm{t}) = Lw(t) + \alpha_{lw}.\begin{bmatrix} Pos\big(Sw(t) - Lw(t)\big).\big(1 - Lw(t)\big) - \\ Pos\left(-\big(Sw(t) - Lw(t)\big)\right).Lw(t) \end{bmatrix}.\Delta\mathrm{t} \qquad (4.43)$$

4.4 Integration of Agents Model of Interview Metal State

This section presents the unification of the factors of the three constructs (self-efficacy, motivation and anxiety) and discusses the blueprint for the integrated conceptual model. The intelligent engine to be incorporated into the interviewee coaching system is a complex system made up of autonomous entities. The functional entities are the individual agents (agent-based models of self-efficacy, motivation and anxiety) that have been designed and formalized in the above sections. These autonomous agent models have to be unified into a solid structure using the common factors and linkages. The result is the integrated cognitive model fulfilling the third objective of this study.

The first sub-section (4.3.1) describes how the constructs are theoretically integrated through common interplays from studies and concepts, some of which were earlier discussed in the previous sections of this chapter. The second sub-section (4.3.2) conceptualized the integrated agent model and the final sub-section (4.3.3) formalizes the integrating factors and dynamic states of the integrated model.

4.4.1 Foundation for the Unification of the Constructs

At the core of the interviewee performance model that explains the interplaying constructs affecting interviewee behaviours during interview session is the interviewee states influence defined by self-efficacy, motivation and anxiety Huffcutt et al. (2011). The fundamental theories that have been hannesed to identify the relationships between the tripatied constructs (self-efficacy, motivation and anxiety) are categorized into appraisal theories and cognitivist theories (Katelin Piniel & Csizér, 2014). Centrak to these unification theories is the Social Cognitive Theory (SCT) which is based on the premise that –people function as contributors to their own motivation, behaviour, and development within a network of reciprocally interacting influences” (Bandura, 1989). Within this theoretical perspective, persons are characterized in terms of a number of basic capabilities. Reciprocal causation reflects the interaction between thought, affect and action. It defines factors such as expectations, beliefs, self-perceptions, goals and intentions to give shape and direction to behaviour. To this extent therefore, the thinking, belief, feelings, and emotions of people affect their behaviours and the natural and extrinsic effects of their actions, conversely, determine their pattern of thoughts and emotions (Bandura, 1997; Wood & Bandura, 2013). Being a theory of human existence in relation to environment, it has been used to define the three constructs individually and collectively. In addition, the individual bases are self-efficacy (Chang et al., 2013; Ouweneel, Schaufeli, & Le Blanc, 2013; Vancouver & Purl, 2017), motivation (Austin, Hammond, Barrows, Gould, & Gould, 2018; Hartnett, 2016; Monteiro de Castro, Reis

Neto, Ferreira, & Gomes, 2016), and anxiety (Q. et al., 2017; Ratten, 2015, 2015; van Deursen, Bolle, Hegner, & Kommers, 2015). At unification are studies on Self-efficacy and motivation (Baylor, 2011; Chang et al., 2013; Hulleman et al., 2016; Olusola, 2011; Schunk, 1991), self-efficacy and anxiety (Baker, Thatcher, Gundlach, & McKnight, 2014; Barrows et al., 2013; Tahmassian & Moghadam, 2011; Tan-Kristanto & Kiropoulos, 2015), motivation and anxiety (Sanadgol & Abdolmanafi-Rokni, 2015; Schwartz, 2018; Su, 2017; Wilson, 2008).

This study is in line with the appraisal and cognitive theories as it identified with the fact that appraisal is an elicitor of emotions (Smith & Kirby, 2009). Further in anxiety building is the recognition that threats (stressor) prompts the process of cognitive appraisal to evaluate the threat and elicits the emotion of worry (anxiety) (Wells, 1999). Coping potential has been related strongly to appraisal situation in worry formation. However, the definition of coping as “an assessment of the individual’s ability to act on the situation” is closely linked to the construct of self-efficacy (Katalin Piniel & Csizér, 2013). Self-efficacy beliefs regulates motivation by the central role it plays in initiating coping behaviour, as well as the amount and the duration of effort invested in action (Zimmerman, 2000). Therefore, self-efficacy is seen in this study as the cognitive determinant of anxiety and also a strong influencer on motivation. In addition is the feedback mechanism strengthening the interactions between motivation, progress on goal, experience, and affect (Carver, 2001). If the goal is accessible with the help of available resources, emotion enhances approach behaviour therefore decreasing the discrepancy of the present and target state, and generating positive experience which enhances the level of self-efficacy. Conversely, inaccessibility of goal due to less coping resources generates negative emotions (worries) which causes avoidance behaviour (belief about worry), and this widened the distance between the current state and the desired state, hence resulting to low sense of self-efficacy from negative experience.

In summary, high level of self-efficacy will lower the levels of anxiety and resulting to higher levels of approach motivation. This implies that interviewee with high level of self-efficacy is likely to have more positive experience that will increase motivation and reduce anxiety. Conversely, a lower sense of self-efficacy is associated with higher levels of anxiety and lower approach motivation, which is often linked to lower levels of positive experience (or at times even negative experience) of performance. Consequently, the tripartite constructs of motivation, cognition (self-efficacy), and affect (anxiety) should be treated as parts of one intertwined framework when mental process is being investigated (Dörnyei & Macaro, 2010).

The review of these fundamental constructs have seen common external and internal factors as well as the output states of a construct causally influencing another construct. Leveraging on these interplays, an integrated model is designed and formalized in the sections that follow to show patterns corresponding to already established phenomenon in the three constituent autonomous agent models. The connecting factors are as presented in Table 4..4 below.

Table 4.4

Unified External Factors

Factors	Self-efficacy	Motivation	Anxiety
Trait Anxiety			x
Verbal persuassion	x		
Vicarious experience	x		
Personality	x	x	x
Prior experience	x	x	x
Task demand	x	x	
Social support	x	x	
Personal autonomy		x	x
Percieved Relatedness		x	
(Interviewer disposition)			

Table 4.5

Unified Internal Factors

Internal States	Self-efficacy	Motivation	Anxiety
Perceived difficulty		x	x
Task skill	x	x	
Threat		x	x
Persistence	x	x	
Goal	x	x	

Table 4.6

Inter-model Connections

Sending States	Receiving states		
	Self-efficacy	Motivation	Anxiety
Long-term Worry (Anxiety)	x		
Long-term Efficacy (Self-efficacy)		x	x
Long-term Motivation (Motivation)	x		

4.4.2 Conceptual Model of an Integrated Agent Model

Based on the structural representation of the integration in the previous chapter (Section 3.5.5), Figure 4.15 shows the proposed integrated model. At the input flank are the circles for input factors to a single agent model, the square objects are for factors shared by two of the agent models while the circled fused in square objects are for factors shared by all the three agent models. The dotted rectangular boxes separate each agent models, the thin solid connectors define the causal dependencies of states within an agent model while the thin dotted connectors denotes link from sharable state between agent models. The connection of output of an agent model to an internal state of another agent model is denoted by the thick solid connectors. The grey coloured internal nodes represent the common (shareable) factors between agent models while the stripe nodes are the temporal factors which are the observable outcome of the model.

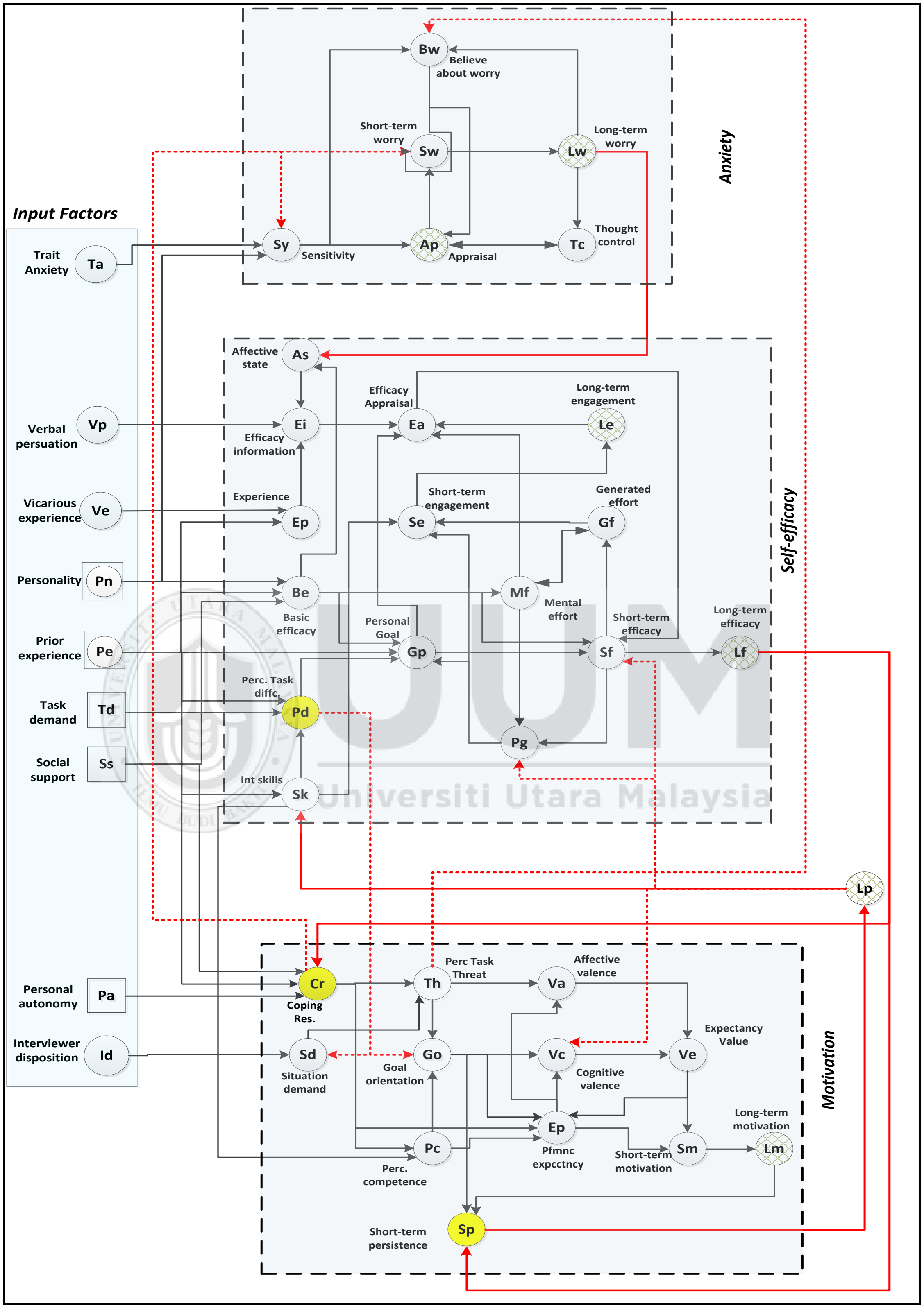

Figure 4.15. Integrated Agent Model of Interviewee Mental State

The integrated model shown in Figure 4.15 has three constituents' models representing the three constructs. The interplays are according to the identifiable relations shown in Tables 4.4 to 4.6.

4.4.3 Formalization of the Integrated Agent Model

The formalization of the model is based on dynamic casual impacts of factors with respect to time (*t*) (Nunes & Luck, 2014). Since the constituent agent models have been formalized earlier, the formalization in this section is targeted only at the introduced factors for integration, unifying state factors and temporal dynamic states.

Instantaneous Relationships

Equation (4.48) presents interviewee skill (*Sk*) defined by the inherent skill that is increased by prior interview experience (*Pe*) and long-term persistence (*Lp*) to performing in the current interview. The *LP* in this context is derived from the persistence by the Self-efficacy (*Lpe*) and that of motivation (*Lpm*). The equation for (*Lp*) is shown in Equation (4.55)

$$Sk(t) = \gamma_{sk} . \mathrm{SK}_{norm} + \left(1 - \gamma_{sk}\right).\left(\omega_{sk}.Pe(t) + (1 - \omega_{sk}).Lp(t-1)\right) \tag{4.48}$$

Coping resources (*Cr*) is defined by the aggregate impact of prior experience (*Pe*), personal autonomy (*Pa*), social support (*Ss*) and influenced significantly by perceived self-efficacy (*Lf*) as shown in Equation (4.49). Coping resources is shared by threat building component of both the motivation and anxiety agent model, consequently the integrated model shared (*Cr*) as single state.

$$Cr(t) = \omega_{cr1}.Pe(t) + \omega_{cr2}.Ss(t) + \omega_{cr3}.Lf(t) + \omega_{cr4}.Pa(t) \tag{4.49}$$

Perceived task demand (*Pd*) is a factor of threat building conceptualized from the interpretation of task difficulty based on experience on similar task and acquired skills. High level of experience and acquired skills ultimately reduce the perceived task (interview) demand during the interview session. *Pd* plays vital role in defining the causal effects of the perception of the actual interview session by the interviewee in each of the constituent agent models. The formalization is as depicted in Equation (4.50).

$$Pd(t) = Td(t).\left(1 - \left(\omega_{pd1}.Pe(t) + \omega_{pd2}.Sk(t)\right)\right) \tag{4.50}$$

Affective state (*As*) connects anxiety and self-efficacy as represented in Equation (4.51). Long-term worry (*Lw*) of the anxiety agent model impacts positively on the affective state of the self-efficacy agent model and negatively by the basic efficacy (*Be*) factor.

$$As(t) = Lw(t).\left(1 - Be(t)\right) \tag{4.51}$$

Persistence at short-term (*Sp*) is defined from the constructs of self-efficacy (*Lf*) and motivation (*Lm*), and strengthened by goal (*Gl*).

$$Sp(t) = \left(\gamma_{sp} . Lf(t-1) + \left(1 - \gamma_{sp}\right).Sm(t-1)\right).Gl(t) \tag{4.52}$$

Temporal Relationships

Long-persistence is the contributory persistence from both motivation and self-efficacy agent models. Long-term persistence was earlier modeled for both self-efficacy and motivation in Equations (4.16) and (4.34) as the accumulated presence of short-term persistence levels of each model respectively. While Equations (4.53) and (4.54) respectively redefine the persistence of self-efficacy and motivation agent models, Equation (4.55) represents the internal working variable for connections of the generalized long term persistence.

$$LpM(t + \Delta t) = LpM(t) + \alpha_{lp}.\left[\left(SpM(t) - LpM(t)\right).LpM(t).\left(1 - Lp(t)\right)\right].\Delta t \tag{4.53}$$

$$LpE(t + \Delta t) = LpE(t) + \alpha_{lp}.\left(SpE(t) - LpE(t)\right).LpE(t).\left(1 - LpE(t)\right).\Delta t \tag{4.54}$$

$$Lp(t) = \omega_{lp}.LpM(t) + \left(1 - \omega_{lp}\right).LpE(t) \tag{4.55}$$

4.5 Summary of the Chapter

This chapter explains the design and development of formal models for self-efficacy, motivation and anxiety in the domain of interview. These models were designed based on theories and empirical studies related to the domain as clearly defined in the literature. These conceptual models were broken down mathematically into various equations that make up their formal representation that can be simulated using a computer program. Subsequently, the interplays between the constructs are identified through the common factors. The major linkages are where the output factor(s) of a construct serves as an input factor(s) to another construct. Later, those models were combined into an integrated cognitive model to simulate overall interviewee mental states, and follows formalization of the model.

The next chapter (Chapter 5) presents the simulation of the various agent models and the integrated model where known cases in the literature are tested and compared with the simulation results.

CHAPTER FIVE

SIMULATION RESULTS

5.1 Introduction

This chapter presents the simulation results of the three agent models of interview self-efficacy, motivation and anxiety, as well as the integrated model based on the design and formalization in Chapter four. The results of the constituent agent models are presented in different sections. Sections 5.3, 5.4, 5.5 and 5.6 shows the simulation results of interview self-efficacy, motivation, anxiety and integrated model respectively based on scenarios contrived to represent relevant cases in psychology. Finally the chapter is summarized in Section 5.7.

5.2 Simulation Results of the Agent Models

The designed agent models were executed using a numerical programming platform to simulate a large number of conditions of fictional individuals. With a variation of these conditions, some interesting patterns are obtained. Several parameters are varied to simulate different characteristics. However, in this study, the duration of the simulation is fixed at 500-time steps (t_{max} = 500) to simulate an interview session. This simulation time represents the regulated time set for an interview. Therefore, it means that for an average interview session of 2 hours, each second of the interview will represent approximately four time steps of the simulation traces. Other parameter values are set accordingly and described in each of the agent model simulation sections. The parameters settings were selected such that the exhibited patterns were related to known behaviours of the constructs in the domain literature. The values of the static parameters are merely to tune the behaviour of the model to expected degree, hence may not stand outside this particular simulation experiments. Values were allocated to the weight of each factor based on their identified strengths of contributions in the literature. The parameters are estimated by changing their values with several running of the simulation. This allows the determination of the most suitable parameter values for the model as consequences to be matched with the literature.

In this processes, while some parameters are changed consistently during the course of running the simulation others are preserved to evaluate the conditions until the reasonably expected trajectories suffice, as done in (Bosse et al., 2009; Both, Hoogendoorn, Klein, & Treur, 2015). The simulation process begins with the initial values to execute the cyclic relations. During the experiments, all conditions are bounded within $0 \geq x(t) \geq 1$, and the iteration continues until several equilibria points are achieved (Treur, 2016c; Vancouver & Weinhardt, 2012). All states in the models have values between 0 and 1 and the new value of a state is determined by preceding states and the previous value of that state. The varied starting values in each simulation cases have no impact on the final expected stability points. Figure 5.1 shows a sample case of a factor with different starting values buts still converges at stability points.

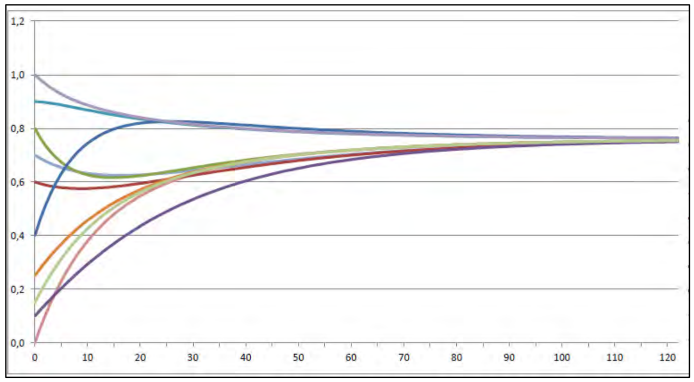

Figure 5.1. Example simulation of different agents converging from different start values

5.3 Simulation Results of Agent Model of Interview Self-Efficacy

Three different scenarios were simulated and observed for analysis of the agent model of interviewee self-efficacy. The simulated results for the given scenarios are depicted in Figures 5.2, 5.3 and 5.4. The detailed simulation parameter and weight setting is presented in Table 5.1 and the simulation code is presented in Appendice G.

Table 5.1

Parameter Settings for Self-Efficacy Model Simulations

Settings	**Values**
t_{max}	The maximum simulation time allocated in seconds is 500. The allocated time of 500s represents the allowable time for the live interview.
Δt	The observable time step is 0.3 second at which change in values is observed and plotted.
Weight	
Anxiety in affective state	ω_{as}=0.5
Mastery experience	ω_{ep}=0.5
Short-term persistence	ω_{sp1}= ω_{sp2}= ω_{sp3}= ω_{sp4}=0.25

Table 5.1 continued

Short-term efficacy	ω_{sf1}=ω_{sf2}=0.5
Long-term persistence	ω_{lp}=0.5
Generated effort	ω_{gf}=0.5
Progress on goal	ω_{pg1}= ω_{pg2}= ω_{pg3}=0.33
Short-term efficacy	ω_{sf1}=0.34, ω_{sf2}= ω_{sf3}=0.33
Efficacy appraisal	ω_{ea1}=ω_{ea2}=0.5
Regulating parameters	
Efficacy appraisal	α_{ea}=0.6
Efficacy information	α_{ei}=0.5
Long-term persistence	α_{lp}=0.5
Basic efficacy	β_{be}=0.5
Short-term engagement	β_{se}=0.5
Long-term engagement	β_{Le}=0.5
Skill	γ_{sk}=0.1
Mental effort	γ_{mf}=0.5
Short-term efficacy	γ_{sf}=0.5
Long-term self-efficacy	γ_{lf}=0.5
Personal goal	ρ_{gp}=0.5
Progress on goal	φ_{pg}=0.8
Mental effort	ψ_{mf}=0.5
Short-term efficacy	λ_{sf}=0.7

Scenario #1: ***Agents with varied exogenous variables***

In this scenario are two extreme cases of high and low and one intermediate level self-efficacy conditions to be tested. Therefore, conditions are set to evaluate three individuals with different conditions to define a high-level efficacy, low-level efficacy and an average efficacious case. The importance is to check the alignment of the simulation results in these cases to suggested results in the literature under similar inputs. Table 5.1 contains the values of the inputs to three agents where high condition identified as (Agent A), low condition as (Agent B) and average condition as (Agent C). The input values rage from 0 (Low) to 1(High). For the purpose of the simulation experiment, 0 is assigned to low input factors, 1 to high input factors and 0.5 for average input factors. The simulation behaviour is presented in Figure 5.2.

Table 5.2

Input Values for Fictional Individuals (Agent A, Agent B, and Agent C)

Factors	**Agent A**	**Agent B**	**Agent C**
Social Support (*Ss*)	1	0	0.5
Personality (*Pn*)	1	0	0.5
Mastery experience (*Me*)	1	0	0.5
Anxiety (*Ax*)	0	1	0.5
Verbal persuasion (*Vp*)	1	0	0.5
Vicarious experience (*Ve*)	1	0	0.5
Task demand (*Td*)	0	1	0.5
Skill (Sk_n)	1	0	0.5

Figure 5.1 below is the graphical simulation result of the input values presented in Table 5.2.

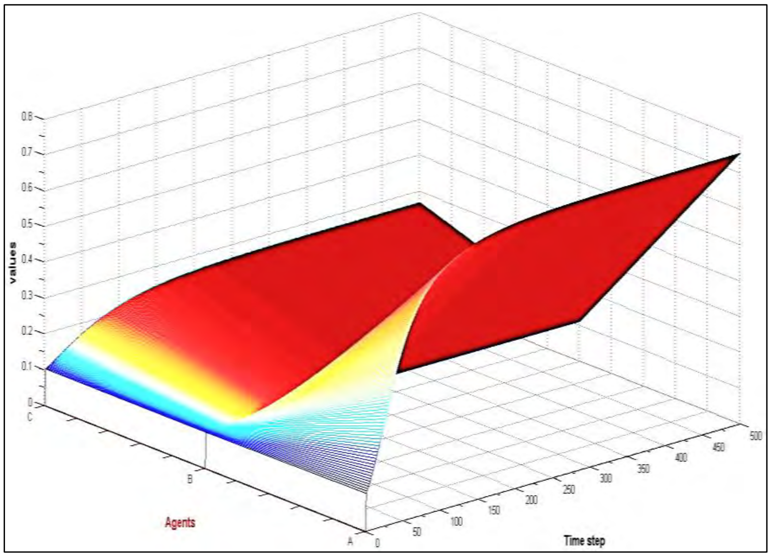

Figure 5.2. Simulation results of self-efficacy for different initial inputs

Figure 5.2 shows the simulation results of three fictitious interviewees (*Agents*) with different assigned conditions. While the starting state of the three agents is 0.1, *Agent A* is seen to possess high competency level and belief in its competency hence the rise in self-efficacy sharply to 0.78. This is line with the fact that all the indices for enhancing high level of self-efficacy is in its favour. An individual with previous experience on interview and high level of support from family or friends, low sense of trait anxiety in addition to positive efficacy experience from vicarious and persuasion is expected to have a high self-efficacy (long-term).

The second extreme case is of *Agent B* with low input factors. It is initialized at 0.1 but the efficacy level maintained a constant low trajectory. This also conforms to the literature that individual without experience, low social support with negative efficacy information during task would develop a low sense of self-efficacy state during task (Leon-Perez, Medina, & Munduate, 2011; Schunk, 1995; Yeo & Neal, 2013). The third case meant to define middle situation showed *Agent C* where the state at 0.1 rises and later maintained a constant state of 0.28 (higher than the start point). However, the third individual with condition (C) attained an average efficacy level due to the middle-level inputs. This category is meant to show the possibility of middle level between the two extreme cases of high and low.

Scenario #2: ***The Effect of Basic-Efficacy and Efficacy Information on Self-Efficacy***

Basic-efficacy is the inherent efficacy level of each individual defined by social support, personality and mastery experience, while efficacy information is acquired during task from mastery experience, vicarious information, verbal persuasion and physiological cue (anxiety) (Ahn et al., 2017; Schunk, 1995). This scenario explains the mediating roles of basic-efficacy and efficacy-information on long-term self-efficacy using four fictional interviewees (*Agents*) with a number of diverse conditions. In this case, *Agent A* and *Agent B* have high basic efficacy but while *Agent A* receives favourable efficacy information during task engagement *Agent B* does not. On the other hand, *Agent C* and *Agent D*, have low basic-efficacy but while *Agent C* receives efficacy information during task *Agent D* does not. The values of inputs to the fictional interviewees (*Agents A*, *Agent B*, *Agent C* and *Agent D*) are given in Table 5.2.

Table 5.3

Initial Inputs for Four Agents with Varied Basic-Efficacy and Efficacy Information

Factors	Agent A	Agent B	Agent C	Agent D
Ss	0.8	0.8	0.1	0.1
Ps	0.7	0.7	0.1	0.1
Me	0.9	0.5	0.5	0.1
Ax	0.2	0.8	0.2	0.8
Vp	0.7	0.1	0.7	0.1
Ve	0.7	0.1	0.7	0.1
Td	0.5	0.5	0.5	0.5
Sk_n	0.6	0.6	0.6	0.6

Based on the input values in Table 5.3, the simulation presents a result that is as depicted in Figure 5.3 below.

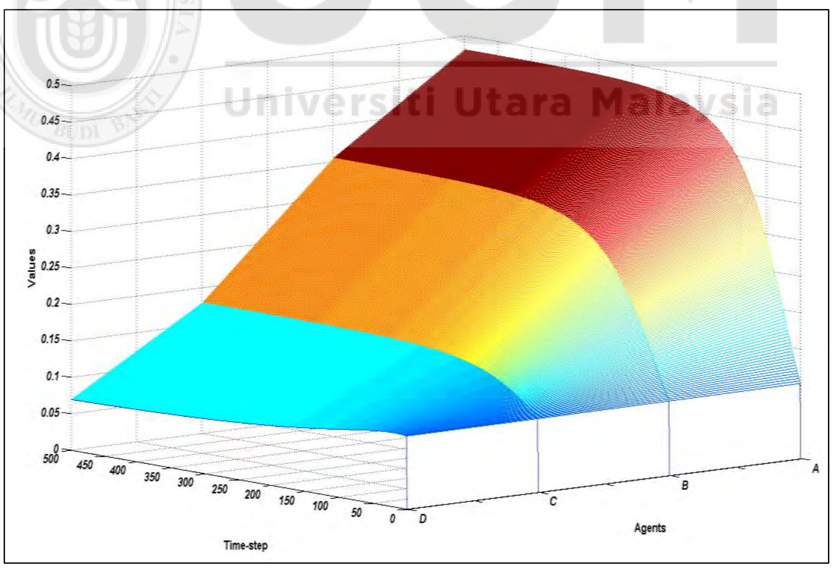

Figure 5.3. The mediating effects of basic-efficacy and efficacy information on long-term self-efficacy

Figure 5.3 shows the influencing role of basic-efficacy and efficacy information on long-term self-efficacy. The impacts on the long-term efficacy shown on the figure support the fact that basic-efficacy is very significant to obtaining appreciable efficacy beliefs in any task irrespective of efficacy information that may be received during the task engagement (Schunk et al., 2012). However, the figure equally proves the strength of efficacy information as individuals that receive it appreciates on their efficacy level at the long-term (Holmes, 2016).

Scenario #3: *Dynamics of Self-efficacy, Persistence and Engagement through Parameter Variation*

This is meant to check the dynamics of the temporal factors (long-term efficacy, long-term persistence and long-term cognitive engagement) through parameters variation. The parameters (β_{le}, α_{lp} and γ_{lf}) are assigned value 0.1 at the first run, 0.5 at the second and 0.9 at a third run (that is, same values for the 3 parameters at 3 different runtimes). Figures 5.4, 5.5 and 5.6 depict the behaviours of the temporal factors accordingly.

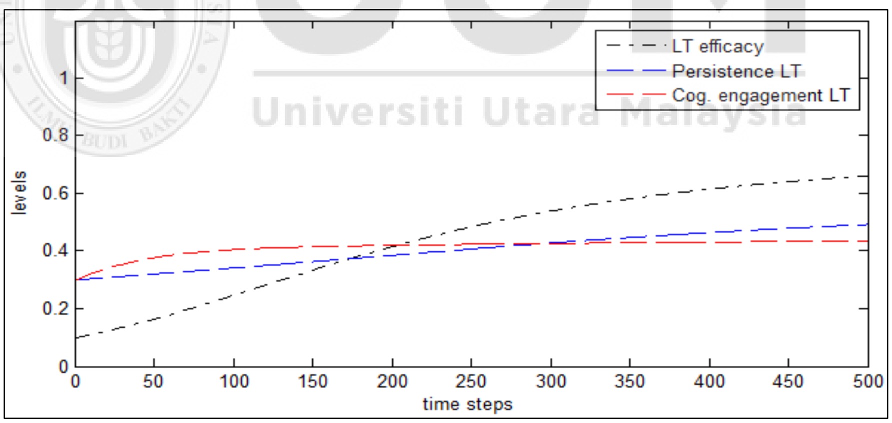

Figure 5.4. Parameter Variations where β_{le}.=0.1, α_{lp}.=0.1 and γ_{lf}=0.1

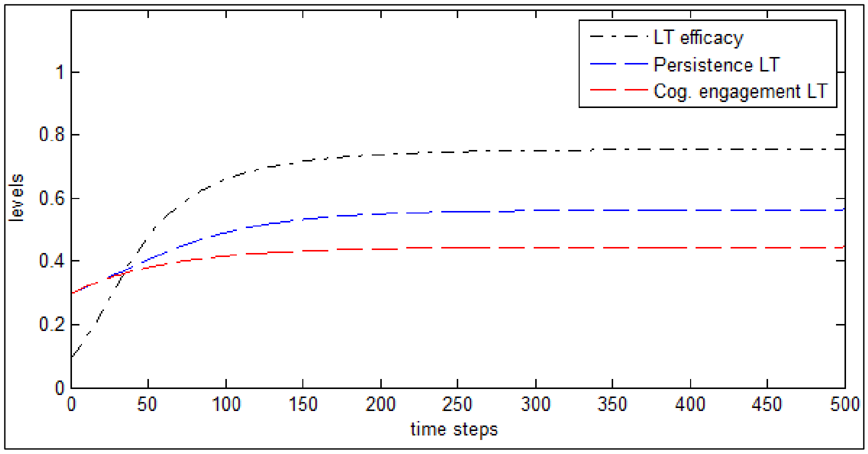

Figure 5.5. Parameter Variations where β_{le}.=0.5, α_{lp}.=0.5 and γ_{lf}=0.5

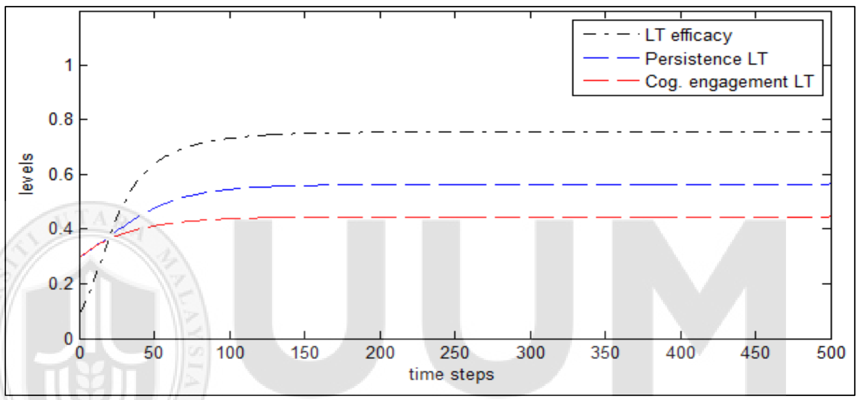

Figure 5.6. Parameter variations where β_{le}.=0.9, α_{lp}.=0.9 and γ_{lf}=0.9

Figures 5.4, 5.5 and 5.6 show the behaviour of the temporal factors with varying parameters. The simulation results show better stability at higher parameters in all the factors. Stability in cognitive engagement will results in stable persistence at the task which invariably stabilizes self-efficacy at high parameters.

5.3 Simulation Results of the Motivation Agent Model

This section presents results for different cases in motivational levels for fictional interviewees during interview tasks. All parameters are tuned to represent different motivational personalities. These personalities (interviewees) are categorized into five different psychological profiles: 1) highly motivated interviewee, 2) low motivated interviewee, 3) interviewee motivation affected by interviewer disposition, 4) self-efficacy effect on interviewee motivation, and 5) personality disposition (anxiety) effect on interviewee motivation. Decay function (λ_{ml}) is introduced to cater for possible decay in motivation. Decay factor determine how fast the previous value of the state decays. All the static parameter values of the models are presented in Table 5.4 and the simulation code is in Appendices H.

Table 5.4

Parameter Settings for Motivation Agent Model Simulations

Weight/Parameter	**Notation = Values**
Weight	
Personal autonomy	$\omega_{pa} = 0.5$
Coping resources.	$\omega_{cr1} = \omega_{cr2} = \omega_{cr3} = \omega_{cr4}$=0.25
Goal	$\omega_{g1} = \omega_{g2} = 0.4, \omega_{g3} = 0.2$
Perceived task difficulty	$\omega_{pd1} = \omega_{pd2}$=0.5
Expectancy value	$\omega_{ep} = \omega_{ep1}$=0.5
Skill	ω_{sk}=0.5
Perceived competence	$\omega_{pc1} = \omega_{pc2} = 0.33, \omega_{pc3} = 0.34$
Control parameters	
Expectancy value	$\alpha_{ep} = 0.5$
Cognitive valence	$\alpha_{cv} = 0.5$
Affective valence	λ_{av}=0.5
Short term motivation	λ_{sm}=0.5
Short-term persistence	$\rho_{gp} = 0.5$
Long-term motivation	$\beta_{lm} = 0.5$
Long-term persistence	$\alpha_{lp} = 0.5$
Decay function	$\lambda_{ml} = 0.001$

The initial values for the external factors to define each of the personalities are presented in Table 5.5.

Table 5.5

Initial Values of Simulation Experiment

Factors	**Agent A**	**Agent B**	**Agent C**	**Agent D**	**Agent E**
Perceived autonomy *(Pa)*	1	0.9	0.1	0.9	0.9
Relatedness *(Rd)*	1	0.9	0.1	0.9	0.9
Social support *(Ss)*	0.8	0.1	0.9	0.9	0.9
Personality *(Pn)*	0.9	0.2	1	0.9	0.1
Task Demand *(Td)*	0.1	0.8	0.9	0.2	0.2
Previous experience *(Pe)*	0.8	0.2	0.9	0.9	0.9
Self-efficacy *(Se)*	1	0.1	1	0.1	0.9
Basic skills *(SK_{norm})*	0.9	0.2	0.9	0.9	0.9

Scenario #1: ***High motivated Interviewee (Agent A)***

A competent and positive personality individual will be motivated to perform in an interview task in a favourable interview environment where the interviewee's feel of relatedness to the interviewer is high (i.e. positive interviewer disposition) (Fonseca et al., 2014). The performance expectancy and value is shown in Figure 5.7(a) while 5.7(b) shows the motivation for the event.

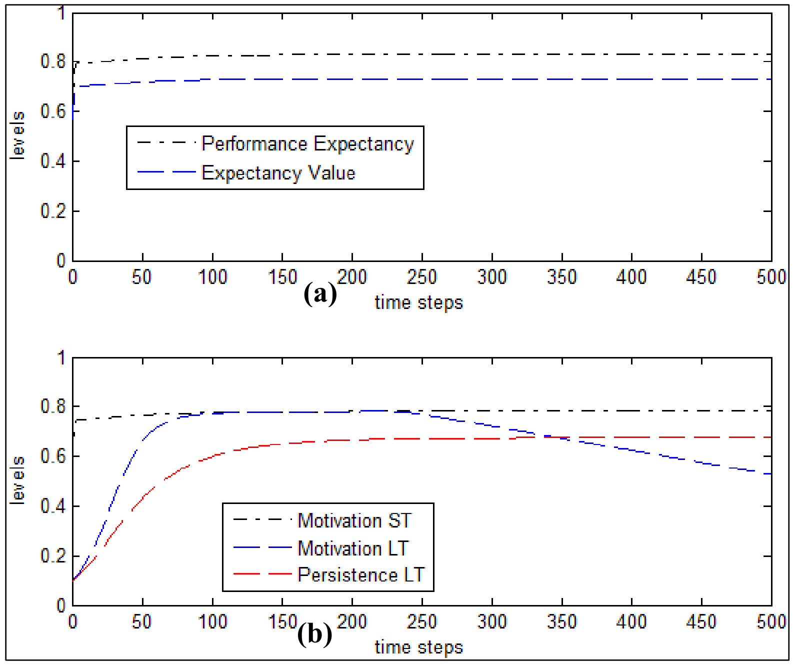

Figure 5.7. Simulation results for a high motivated interviewee with high sense of perceived relatedness during interview

Figure 5.7 visualizes the scenario of a positive personality who believes in his/her competence engaging in solving the task (interview session) and perceived it as "not demanding". The discrepancy is connected to the low value of task difficulty. In this case, the long-term motivation maintained a high value with short-term motivation but declines in due course owing to decay. Motivation may be weakened as a result of long term engagement with same level of results, external distraction or negative feelings (Paoletti & Cigognini, 2015; Schunk & Pajares, 2009). This decay may be occasioned by differences in need satisfaction (autonomy, competence and relatedness) or general alteration in test environment due to time (Gnambs & Hanfstingl, 2016).

Scenario #2: ***Behaviour of Non-Motivated Interviewee (Agent B)***

The scenario is that of interviewee that is less competent in terms of skills, in an interview environment he/she perceives as high demanding. The performance expectancy and value is shown in Figure 5.8(a) while 5.8(b) shows the motivation for the event.

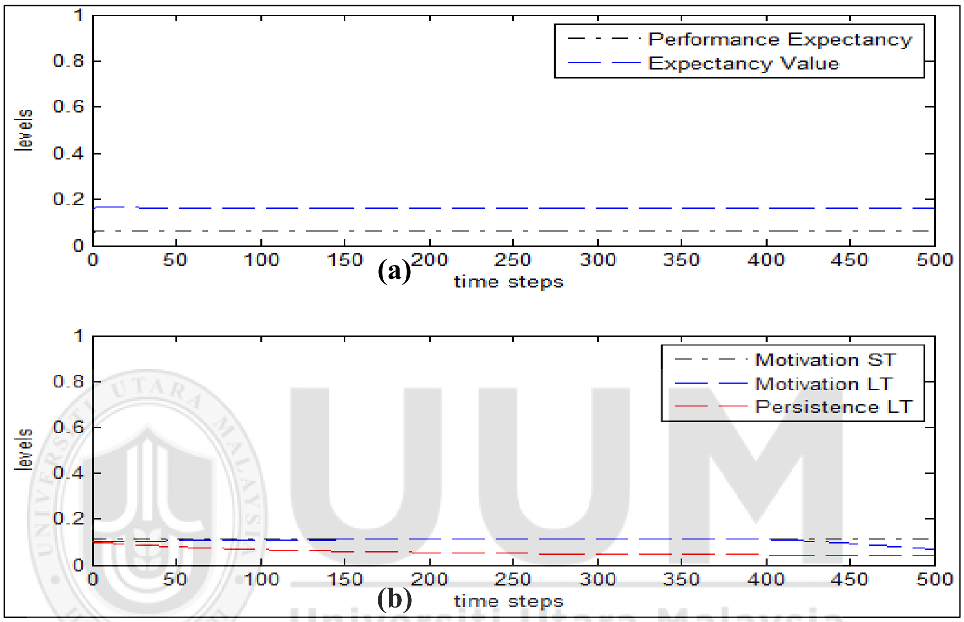

Figure 5.8. Simulation results of low motivated interviewee

The simulation result shown in Figure 5.8 represents the condition for low motivated individual due to the unfavourable social and environmental conditions and demands. In addition, the individual will experience the low motivation and persistence regardless the favourable behaviours of the interviewer. Expectancy-value is higher than performance expectancy is a condition that can be analysed as due to high task demand (Wigfield & Eccles, 2000). As seen in the simulation results, because the task demand is perceived high by the interviewee, Figure 5.8(a) shows performance expectancy being lower than the value associated to it (expectancy value). These are key indicators to low motivation as shown in Figure 5.8(b).

Scenario #3: ***Effect of interviewer disposition on motivated interviewee (Agent C)***

In this case the interview environment factors are favourable except for the interviewer disposition that is negative. The interest is to see if the character of the interviewer has a significant impact on the overall motivational effect of the interviewee. The performance expectancy and value is shown in Figure 5.9(a) while 5.9(b) shows the motivation for the event.

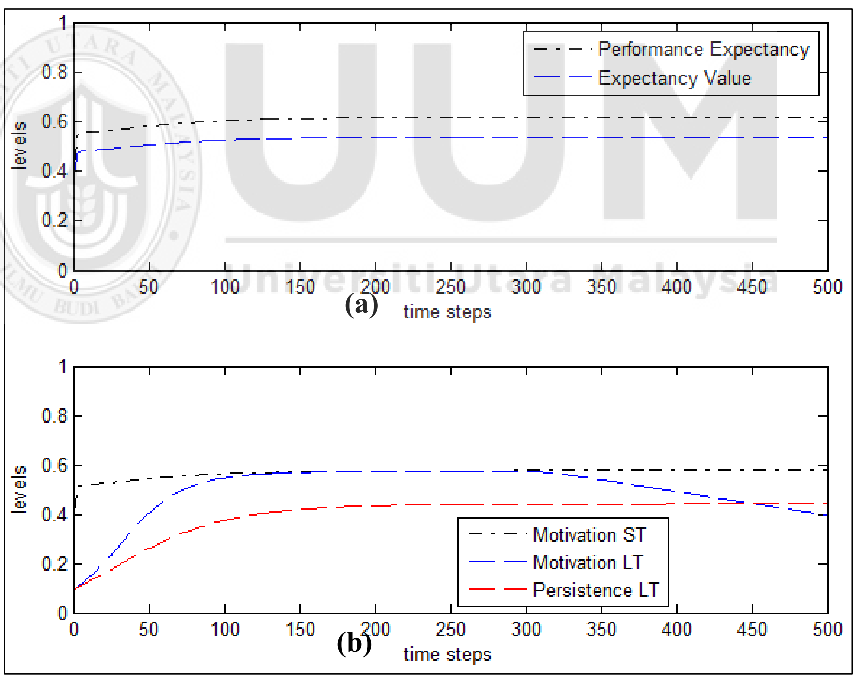

Figure 5.9. Simulation results of the effect of interviewer disposition on motivated interviewee.

Figure 5.9 shows that there is a marginal effect of an interviewer disposition towards interview motivation and persistence. This is observed by the drop in the motivation and persistence level by 2 points when Figure 5.9 is compared to Figure 5.7. This is in line with the fact that a negative character interviewer imposes a sense of non-relatedness on the interviewee which can induce task-specific threat that has negative causal effects on goal orientation and affective values. This is capable of reducing motivation level of an interviewee during the session (Deci & Ryan, 2012).

Scenario #4: ***Effect of self-efficacy on motivated interviewee (Agent D)***

The scenario simulates the effect of Self-efficacy on interviewee motivation and persistence. The performance expectancy and value is shown in Figure 5.10(a) while 5.10(b) shows the motivation and persistence on the task.

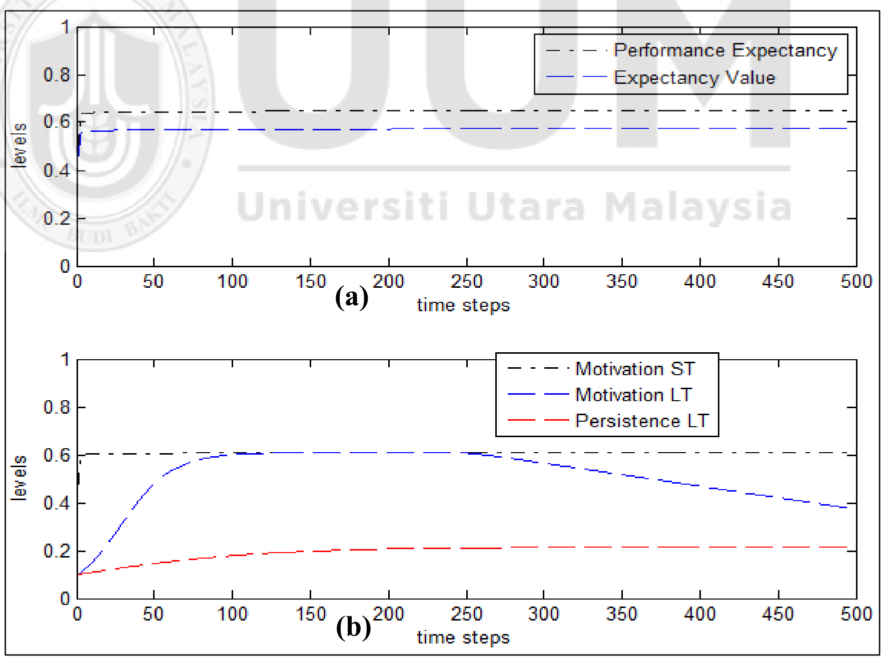

Figure 5.10. Simulation results showing the effect of self-efficacy on motivated interviewee

The scenario depicted in Figure 5.10 aims to show the effect of self-efficacy on both motivation and persistence. Though the effect of low self-efficacy is shown in both motivation and persistence, it is more significant on persistence. Persistence has been defined to connect self-efficacy and motivation. Therefore, a drastic change in self-efficacy has the tendency to show a drastic drop in persistence on the task which invariable reduces the motivation to performance (Lunenburg, 2011; Schunk, 1995). The sharp fall of motivation trajectory after an initial high is as a result of decay in motivation as a result of low persistence in a long term (Paoletti & Cigognini, 2015).

Scenario #5: ***Effect of assertive personality on motivated agent***

The scenario simulates the personality profile (assertiveness) on motivation. The performance expectancy and value is shown in Figure 5.11(a) while 5.11(b) shows the motivation for the event.

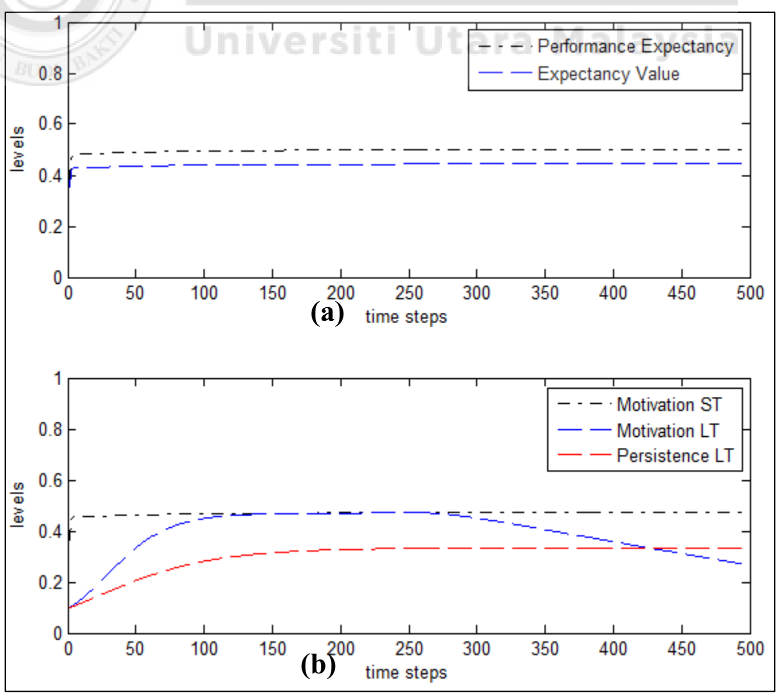

Figure 5.11. Simulation result of the effect of assertiveness on motivated interviewee

In this scenario (Figure 5.11), the simulation result shows that personality profile has a great impact on expectancy and value. Despite all the positive inputs, negative personality was able to reduce the motivation effect and with a negative proportion on persistence also (Bencsik et al., 2016).

5.4 Simulation Results of the Anxiety Agent Model

This section presents results for two extreme anxiety cases for fictional interviewees during interview tasks. These cases are 1) highly anxious interviewee, and 2) a non-anxious interviewee. Other cases in the literature are simulated to ascertain the conformity of the results of the agent model under review. Table 5.6 presents the static parameters and the weight values used for the simulation while the simulation code is in Appendix I.

Table 5.6
Parameter Settings for Anxiety Agent Model Simulations

Weight/Parameter	**Notation = Values**
Weight	
Coping resources.	$\omega_{cr1} = \omega_{cr2} = \omega_{cr3} = \omega_{cr4}$=0.25
Control parameters	
Coping resources	$\alpha_{cr} = 0.5$
Belief about worry	$\gamma_{bw} = 0.2$, $\beta_{bw} = 0.5$
Sensitivity	$\alpha_{sy} = 0.5$
Appraisal	$\beta_{ap} = 0.5$
Long-term worry	$\alpha_{lw} = 0.5$
Short-term worry	φ_{sw}=0.7, σ_{sw}=0.5
Observable Time Change	Δt=0.2 secs

The inputs to define the two aforementioned cases are presented in Table 5.7 below. The interviewee in each of the cases is represented as Agents.

Table 5.7

Values of the Input Factors for the Two Extreme Cases

Input factors	**Agent A**	**Agent B**
Relatedness (*Rd*)	0.1	0.9
Task demand (*Td*)	0.9	0.1
Self-efficacy (*Se*)	0.1	0.9
Prior experience (*Pe*)	0.1	0.9
Personal autonomy (*Pa*)	0.1	0.9
Social support (*Ss*)	0.1	0.9
Trait anxiety (*Tr*)	0.9	0.1
Personality (*Pn*)	0.1	0.9

Scenario 1: *Behavioural tendencies of interviewee in a non-conducive interview environment (Agent A).*

This scenario simulates a low assertive interviewee with low trait anxiety, low experience, and lacking in basic competency belief (self-efficacy). The result of the simulation for the scenario is depicted in Figure 5.12 for the *Agent A*.

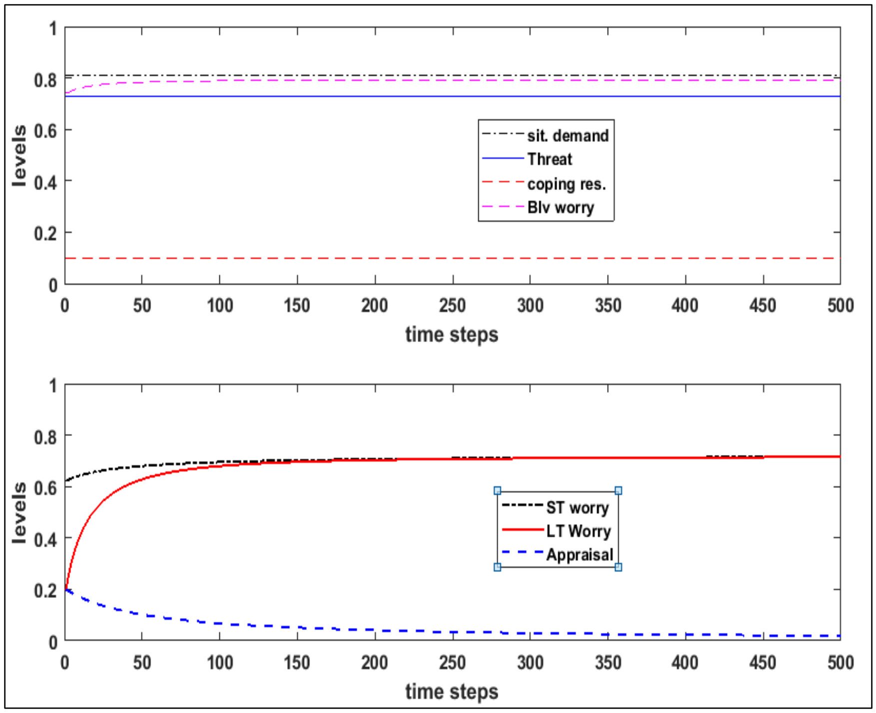

Figure 5.12. Simulation results for an anxious interviewee (*Agent A*)

Figure 5.12 represents the traces of interviewee who is highly sensitive due to inherent anxiety trait. This coupled with perception about task difficulty and low self-efficacy ultimately increases the belief about worry (negative). In consistent with findings in the literature, belief about worry (negative) is inversely proportional to appraisal (positive) and directly proportional to worries. Cognitive worries are manifested if an individual is unable to control his/her thoughts (Borkovec et al., 2004; Powell et al., 2018).

Scenario 2: *Behavioural tendencies of interviewee in a conducive interview condition (Agent B).*

This scenario simulate the behaviour of an assertive interviewee, high in trait anxiety, low in competency belief (self-efficacy), with little or no previous interview experience. The simulation result for this scenario is depicted in Figure 5.13.

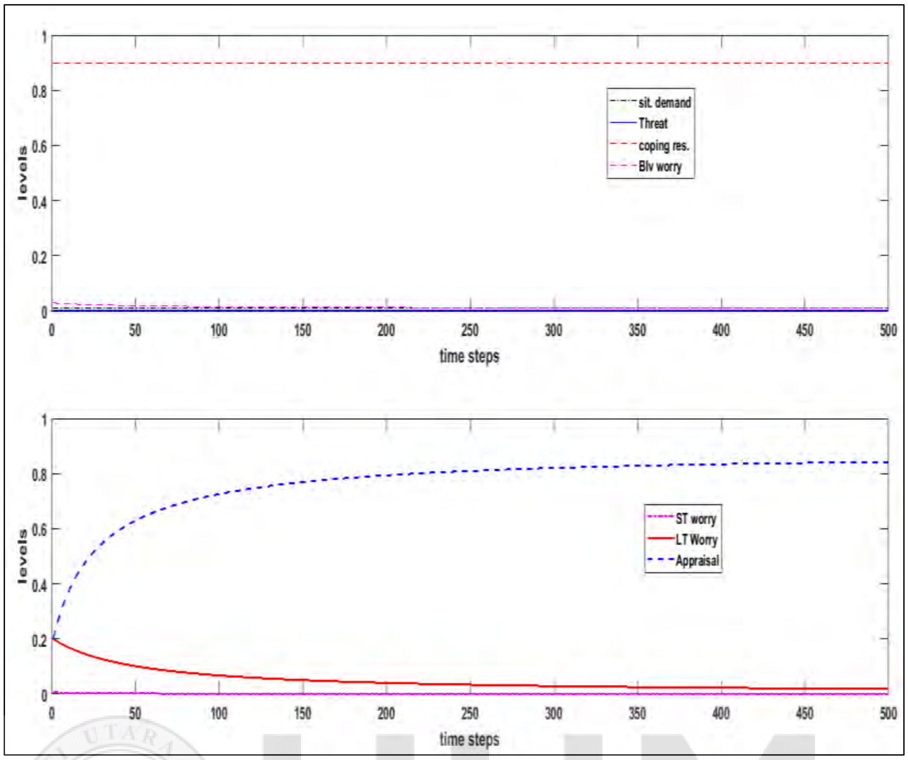

Figure 5.13. Simulation result of a non-anxious interviewee (*Agent B*)

Figure 5.13 presents a situation where the agent's anxiety drops due to confidence obtained from perceived autonomy, belief in competency (self-efficacy) and perceived non-difficulty of the task. Sensitivity is low due to low trait anxiety and high previous experience coupled with high personality (assertiveness) level of the agent (MacDorman & Entezari, 2015). This sensitivity contributed to the lower belief about worry which significantly lowered the short-term worry and subsequently the long-term worry. There is a (positive) *personal appraisal* in this instance of low (negative) *believe about worry* in consistence with literature (Wells, 2005).

Scenario 3: ***Effect of personality factors on anxiety***

This scenario explains the effects of the personality factors (such as assertiveness and trait). This case presents a high personality (that is, high assertiveness and low trait anxiety) in a non-conducive interview environment. The result of the simulation for the scenario is shown in Figure 5.14(a) whereas the earlier case on an Agent where low personality is faced with a non-conducive interview environment is shown in Figure 5.14(b).

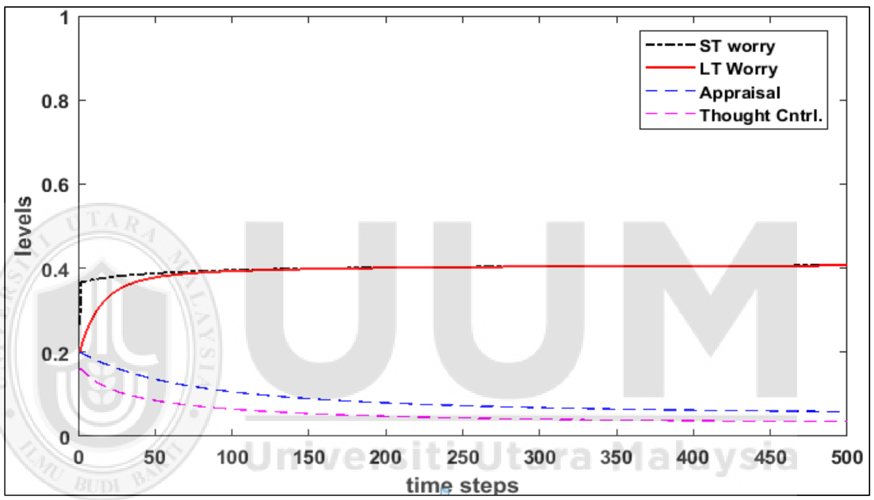

Figure 5.14(a). Simulation result of positive personality factors on anxiety

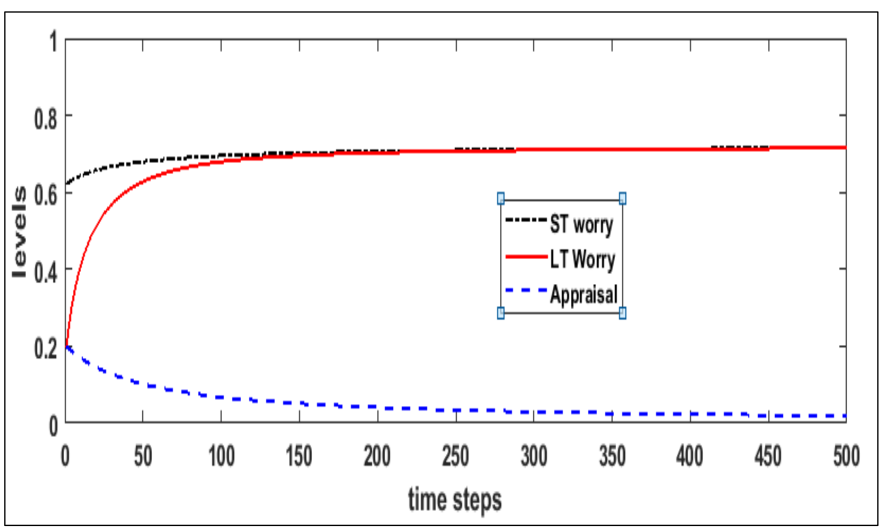

Figure 5.14(b). Simulation result of anxious Agent

The result is presented by the scenario shows a positive effect of assertive personality and trait anxiety on the long-term worry, appraisal and thought control. This effect can be detected by comparing the plot in Figure 5.14(a) with that of Figure 5.14(b). Whereas the final values of long-term worry and appraisal are 0.715 and 0.19 respectively in Figure 5.14(b), the improvement of personality factors in Figure 5.14(a) reduced long-term worry to 0.410 while appraisal dropped to 0.019. This gives credence to the findings in the literature that personality factors contribute immensely to human emotions and affects. Sensitivity concepts is defined by the personality factors and sensitivity commands great influence on appraisal and belief about worry constructs (Skodol, Geier, Grant, & Hasin, 2014; Wells, 1999).

5.5 Simulation of the Integrated Agent Model of Interviewee Mental State

This section presents results of the integrated cognitive agent model for cases where the relationships between the three constructs ensue for an interviewee. The parameter settings and weights assigned to factors are shown in Table 5.8 below while the simulation code is presented in Appendix J.

Table 5.8

Parameter Settings for the Integrated Agent Model Simulations

Weight/Parameter	**Notation = Values**
Weight	
Belief about worry	$\omega_{bw} = 0.5$
Coping resources.	$\omega_{cr1} = \omega_{cr2} = \omega_{cr3} = \omega_{cr4}$=0.25
Perceived task difficulty	$\omega_{pd1} = \omega_{pd2}$=0.5
Perceived autonomy	$\omega_{pa} = 0.5$
Skill	$\omega_{sk} = 0.5$

Table 5.8 continued

Personal goal	$\omega_{pg1} = \omega_{pg2} = 0.33, \omega_{pg3} = 0.34$
Perceived competence	$\omega_{pc1} = \omega_{pc2} = 0.33, \omega_{pc3} = 0.34$
Performance expectancy	ω_{Ep1}=ω_{Ep2}=0.5
Anxiety in affective state	$\omega_{as} = 0.5$
Experience	$\omega_{ex} = 0.5$
Efficacy information	$\omega_{ei} = 0.5$
Goal progress	$\omega_{gp1} = 0.34, \omega_{gp2} = \omega_{gp3}$=0.33
Short-term persistence	$\omega_{sp1} = \omega_{sp2} = \omega_{sp3} = \omega_{sp4}$=0.25
Short-term efficacy	$\omega_{se1} = \omega_{se2}$=0.5, $\omega_{sf1} = \omega_{sf2} = \omega_{sf3}$ =0.33
Efficacy appraisal	$\omega_{ea} = 0.8$
Generated effort	$\omega_{gf} = 0.5$
Long-term persistence	$\omega_{lp} = 0.5$
Control parameters	
Coping resources	$\alpha_{cr} = 0.5$
Belief about worry	$\gamma_{bw} = 0.2$
Sensitivity	$\alpha_{sy} = 0.5$
Short-term worry	ψ_{sw} =0.1, φ_{sw} =0.9
Appraisal	$\beta_{ap} = 0.5$
Long-term worry	$\alpha_{lw} = 0.8$
Skill	$\gamma_{sk} = 0.5$
Performance Expectancy	$\alpha_{Ep} = 0.5$
Cognitive valence	$\alpha_{cv} = 0.5$
Expectancy value	λ_{ve}=0.5
Short term motivation	λ_{sm}=0.1
Short-term persistence	φ_{sp}=0.5
Long-term motivation	$\beta_{lm} = 0.5$
Long-term persistence	$\gamma_{lp} = 0.3, \alpha_{lp} = 0.9$
Decay function	$\mu_{ml} = 0$
Basic efficacy	$\beta_{be} = 0.8$
Short-term efficacy	$\beta_{se} = 0.5$, λ_{sf}=0.2
Efficacy appraisal	$\alpha_{ea} = 0.5$
Mental efforts	$\gamma_{mf} = 0.5, \psi_{mf}$ =0.5
Long-term engagement	$\beta_{le} = 0.9$
Long-term self-efficacy	$\gamma_{mf} = 0.9$

The initial values to define the behaviour of the Agents with the two known extreme cases are presented in Table 5.9 below.

Table 5.9

Initial Values of the Input Factors for the Scenarios in the Model

Input factors	**Agent A**	**Agent B**
Personal autonomy (*Pa*)	0.9	0.1
Relatedness (*Rd*)	0.9	0.1
Social support (*Ss*)	0.8	0.2
Task demand (*Td*)	0.2	0.9
Prior experience (*Pe*)	0.9	0.1
Inherent Skill (Sk_{norm})	0.5	0.5
Trait anxiety (*Tr*)	0.1	0.9
Personality (*Pn*)	0.9	0.1
Verbal persuasion (*Vp*)	0.8	0.1
Vicarious experience (*Vx*)	0.9	0.1

Scenario 1: *Positively induced fictional interviewee (Agent A)*

This scenario presents the behaviour of an *Agent* in a favourable interview conditions (high personality, relatedness, social support and prior experience factors and low in task demand and trait anxiety). The result of the simulation for the scenario is depicted in Figure 5.15.

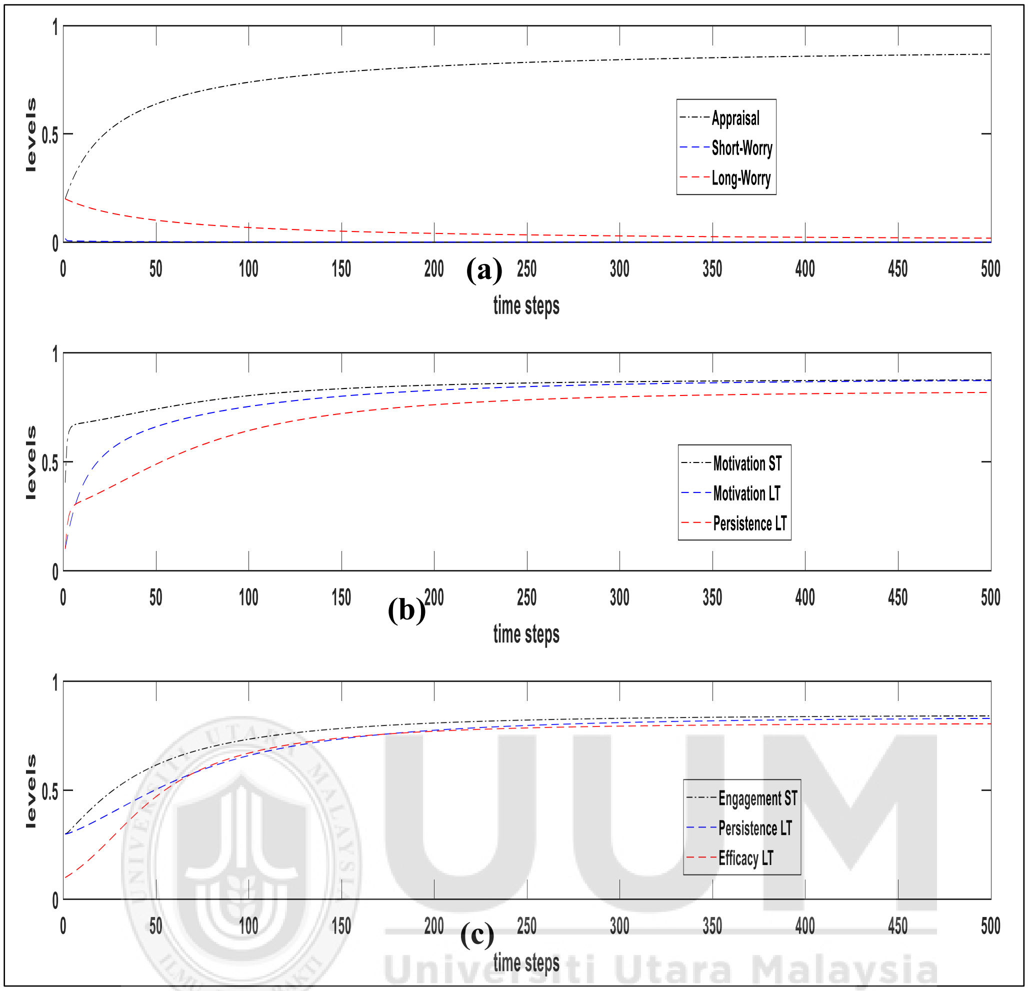

Figure 5.15. Simulation results of the positively induced fictional interviewee

Figure 5.15 visualises the traces of *Agent A*. The result show traces of low anxiety, high motivation and high self-efficacy as represented in the Figure 5.15(a), (b), and (c) respectively. The result shown by the integrated model in favourable initial input values corresponds to the individual agent models as earlier shown in Figure 5.2 (Self-efficacy), Figure 5.7 (motivation), Figure 5.13 (Anxiety) and they are consistent with findings in the domain literature. For Instance, those with a high level of self-efficacy naturally show lower levels of anxiety in test situations, due to the fact that they have beliefs in their ability hence motivated to imagine successful outcome (Barrows et al., 2013; Katalin Piniel & Csizer, 2015; Katalin Piniel & Csizér, 2013).

Scenario 2: ***Negatively induced fictional interviewee (Agent B).***

This is a scenario for an *Agent B* with unfavourable interview conditions. The interviewee is high in trait anxiety and to face the demanding task (low personality, relatedness, social support and prior experience, and high in task demand and trait anxiety). The result of the simulation for the scenario is depicted in Figure 5.16.

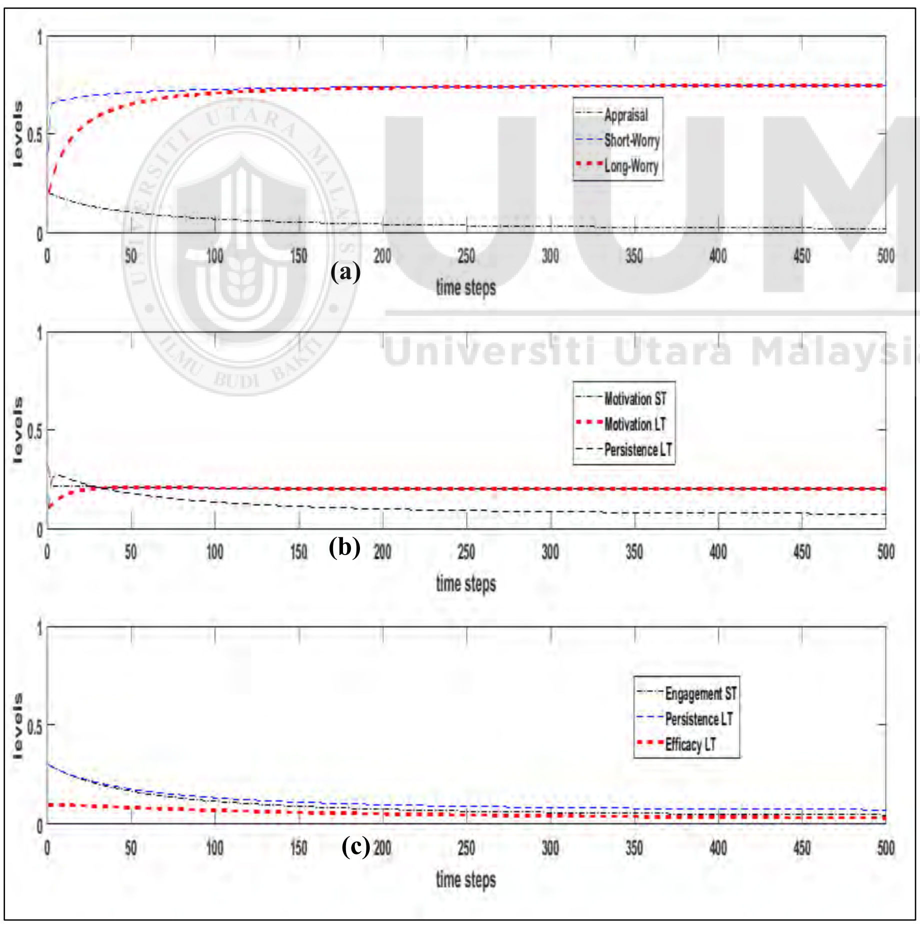

Figure 5.16. Simulation results of a negatively induced fictional interviewee

Figure 5.16 above shows the simulation traces of *Agent B* who is induced negatively with low inputs in personality, autonomy, experience, persuasion, social support and high in task demand and trait anxiety. The trajectories show an anxious *Agent B* (Figure 5.15a), demotivated *Agent B* (Figure 5.16b) and non-efficacious *Agent B* (Figure 5.16c) as identified in the literature. Perceived incompetence (i.e. low self-efficacy) increases test anxiety and decreases motivation through lack of persistence which typically causes an even greater negative effect on performance (Barrows et al., 2013; Katalin Piniel & Csizer, 2015; Schunk et al., 2012). This result of the integrated model also corresponds with the individual agent models for a non-favourable interview situation, for example, in Figures 5.3 (Self-efficacy), Figure 5.8 (motivation), and Figure 5.12 (Anxiety).

Scenario 3: ***The behavioural dynamics of the integrated model***

This scenario presents the changing dynamics of the temporal factors of the model in the two extreme cases of favourable and non-favourable interview situations. The result of the simulation for the scenario is shown in Figure 5.17(a) and 5.17(b).

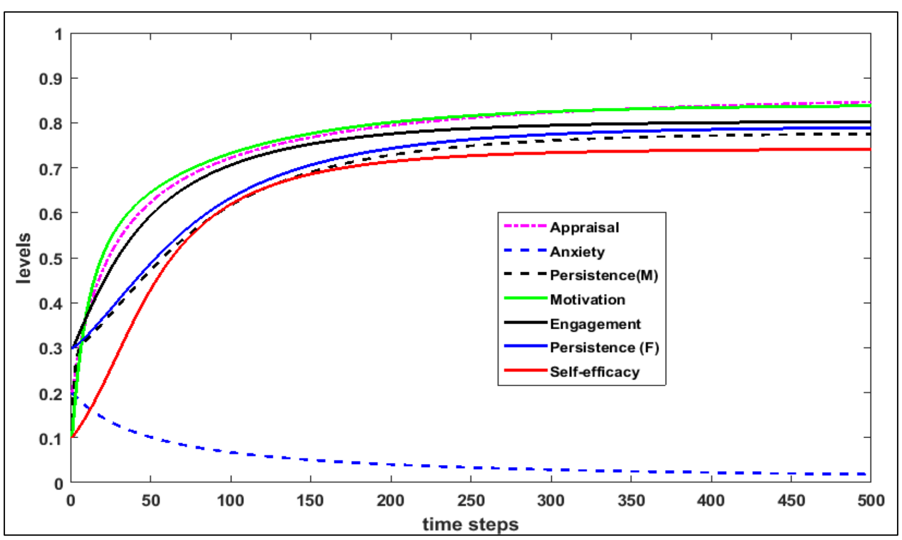

Figure 5.17(a). Simulation result of the dynamics of the temporal factors at a favourable interview condition

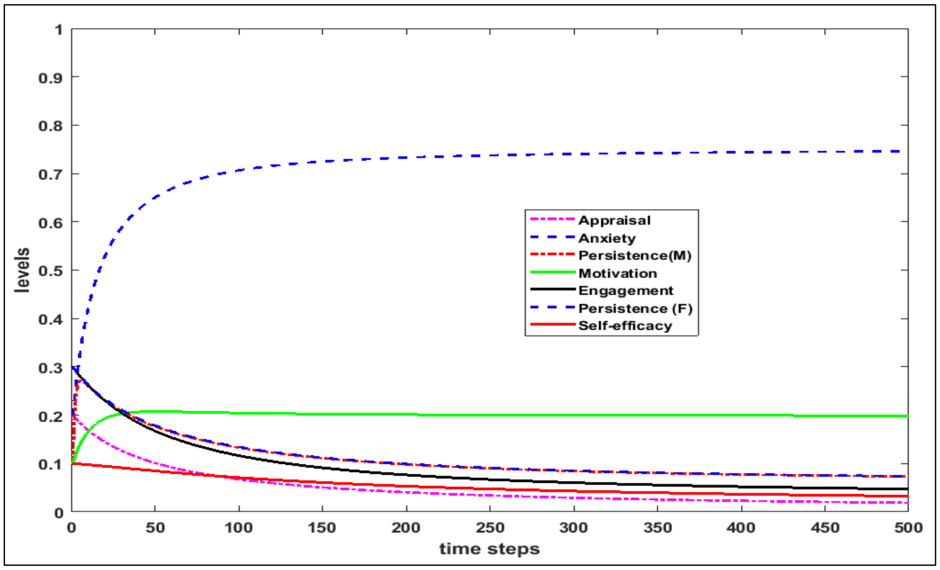

Figure 5.17(b). Relationship of temporal factors at negative environment

The simulation results in Figure 5.17(a) show appraisal of anxiousness moving in conformity with motivation but such alliance cannot be decoded at 5.17(b). The interpretation is that in a favourable interview or test situation, motivation can determine the appraisal and vice-versa but in a negative situation the behaviour of the two factors can't be related (Ahn et al., 2017). Persistence in motivation and persistence in self-efficacy are not exactly same in the positive situation but they move in an equal pattern. However, in a negative interview situation, the two ―persistence" factors are both equal in value as well as a pattern throughout the session. This explains the connecting relationship of persistence to self-efficacy and motivation at the long-run. Positive feedback of self-efficacy induces persistence and engagement and these two are key ingredient to fuel intrinsic motivation (Ouweneel et al., 2013).

Scenario 4: ***Effect of different personality factor on different interview situation***

This scenario analyses the effect of personality factors (assertiveness and trait) on interview situation. Positive and negative personalities are tested on favourable and unfavourable interview situations. The result of the simulation for the scenario is shown in Figure 5.18(a) and 5.18(b).

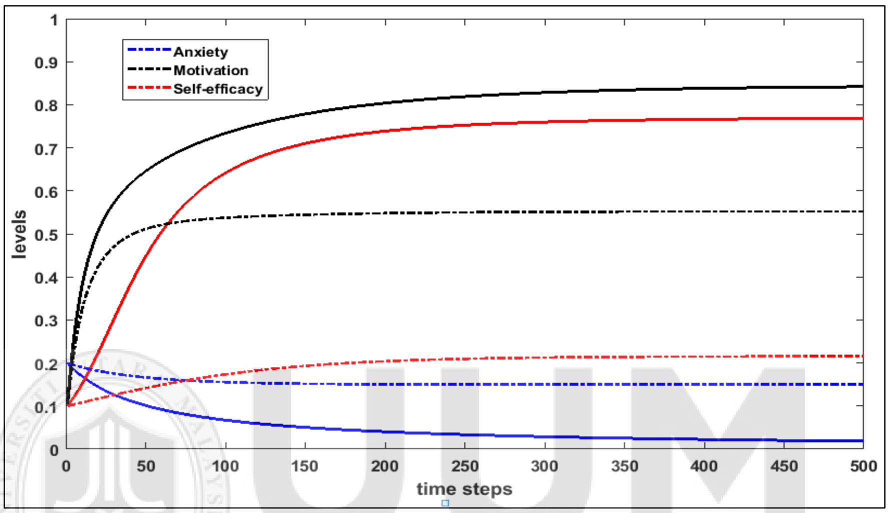

Figure 5.18(a). Effect of negative personality factor on favourable interview situation

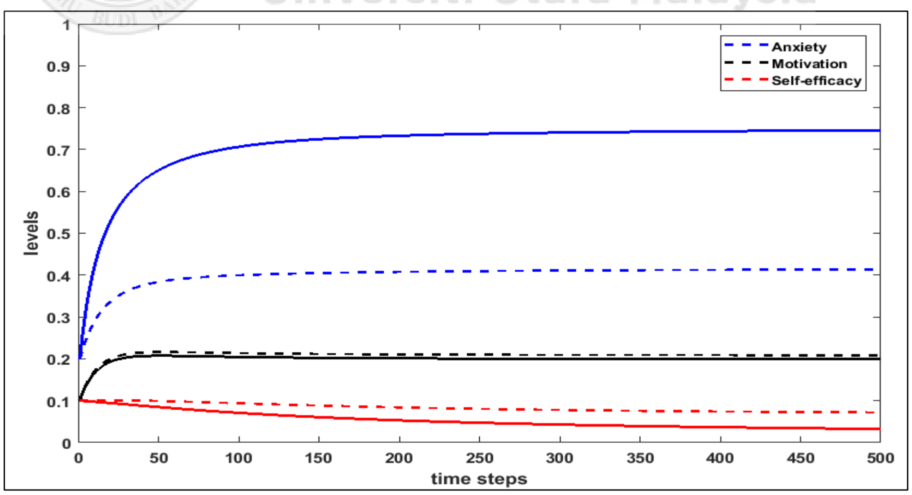

Figure 5.18(b). Effect of positive personality factor on non-favourable interview situation

(Note: The solid lines in the plots represent the initial plots while the dotted lines are the effects of the new personality)

Negative personality affects the three factors in positive interview environment as shown in Figure 5.18(a). However, self-efficacy is much affected which implies that the efficacy of a person can easily drop with a negative change in assertiveness or increase in the trait anxiety (Van den Berg & Feij, 2003). Motivation is also much affected but to a lesser degree. Nevertheless, anxiety increased with this personality negativity but not as much as self-efficacy and motivation (Feiler & Powell, 2015). Figure 5.18(b) presents the negative interview environment injected with positive personality. Anxiety drops drastically in this instance meaning that personality deficiency contributed to the high level of anxiety noticed in the negative interview environment (Skodol et al., 2014). While motivation shows little improvement, self-efficacy shows no changes at this instance. This explains that a low self-efficacy from bad interview environment would still have remained low even if the interviewee has more positive personality. These two cases of personality as its effect the three constructs are subject to further analysis.

5.6 Summary of the Chapter

This chapter shows the results of simulation of all the agent models and the integrated model. Scenarios were defined from the literature relating to each of the constructs and simulations were run to confirm the veracity. Three scenarios were tested for self-efficacy model, five for motivation, three for anxiety and four scenarios for the integrated model. The results of the simulation in all cases support theoretical foundations and empirical postulations in the reviewed literature. Furthermore, the results of integrated model conform to the individual agent models. This is a proof to the internal consistency and face accuracy of the integrated model.

CHAPTER SIX

MODEL EVALUATION

6.1 Introduction

A computational model must be evaluated to ensure that the solution is in compliance with the conceptual description of the theoretical foundations of the construct under review. This chapter is organized into two main branches of evaluation processes which are verification and validation. The two techniques used for verification purposes are mathematical analysis and automatic verification using Temporal Trace Language (TTL). While the temporal equations defined during formalizations in Chapter 4 are used for the mathematical analyses, the simulation codes generated in Chapter 5 are used to run the TTL for the models. Sections 6.2, 6.3, and 6.4 of this Chapter present the verification of the constituent agent models of self-efficacy, motivation and anxiety respectively while the integrated cognitive model is verified in Section 6.5. Finally, the validation of the cognitive agent model (integrated model) is done in Section 6.6.

6.2 Verification of Interview Self-efficacy Agent Model

Section 6.2.1 presents the aspect of mathematical analysis of the self-efficacy agent model while value substitution to proof the accuracy in the stability is shown in Section 6.2.2. Finally, Section 6.2.3 presents the results of the TTL verification.

6.2.1 Mathematical Analyses of Self-Efficacy Agent Model

In order to verify the correctness of the model, the possible equilibria points are analysed. Identifying possible equilibria point is an important method of defining the stability of a simulated model. A significant assumption made is; all exogenous variables are having a constant value and all parameters are non-zero. This is assumptions is applicable to all sections on mathematical analyses in this Chapter.

In analysing the equilibrium points of self-efficacy, equations (6.1), (6.2) and (6.33) are derived where equilibrium states are characterized and deduced respectively from temporal equations 4.15, 4.16, and 4.17, thus;

Equation (4.15)

$$Le(t + \Delta t) = Le(t) + \beta_{le}.\left(\mathrm{Se}(t) - Le(t)\right).\left(1 - Le(t)\right).Le(t).\Delta t$$

Equation (4.16)

$$Lp(t + \Delta t) = Lp(t) + \alpha_{lp}.\left(\mathrm{Sp}(t) - Lp(t)\right).\left(1 - Lp(t)\right).Lp(t).\Delta t$$

Equation (4.17)

$$Lf(t + \Delta t) = Lf(t) + \gamma_{lf}.\left(\mathrm{Sf}(t) - Lf(t)\right).\left(1 - Lf(t)\right).Lf(t).\Delta t$$

derivation of equilibrium

$$dLe(t)/dt = \beta_{le}.(\mathrm{Se} - Le).(1 - Le).Le \quad (6.1)$$

$$dLp(t)/dt = \alpha_{lp}.(\mathrm{Sp} - Lp).(1 - Lp).Lp \quad (6.2)$$

$$dLf(t)/dt = \gamma_{lf}.(\mathrm{Sf} - Lf).(1 - Lf).Lf \quad (6.3)$$

the equations are further identified as follows where change is not expected at equilibrium,

$$dLe(t)/dt = 0$$
$$dLp(t)/dt = 0$$
$$dLf(t)/dt = 0$$

assuming all temporal parameters are equal to 1, therefore these equations can be re-written as,

$$(Se=Le) \vee (Le=1) \vee (Le=0) \tag{6.4}$$

$$(Sp=Lp) \vee (Lp=1) \vee (Lp=0) \tag{6.5}$$

$$(Sf=Lf) \vee (Lf=1) \vee (Lf=0) \tag{6.6}$$

Therefore, the first conclusion can be identified where the equilibria points can only occur when $Se=Le$ or $Le=1$ or $Le=0$ in equation (6.4), $Sp=Lp$ or $Lp=1$ or $Lp=0$ in equation (6.5), and $Sf=Lf$ or $Lf=1$ or $Lf=0$ in equation (6.6).

This assertion is shown in Figure 6.1 where stability point is visualized when $Se=Le$, $Sp=Lp$ and $Sf=Lf$ in the trajectories.

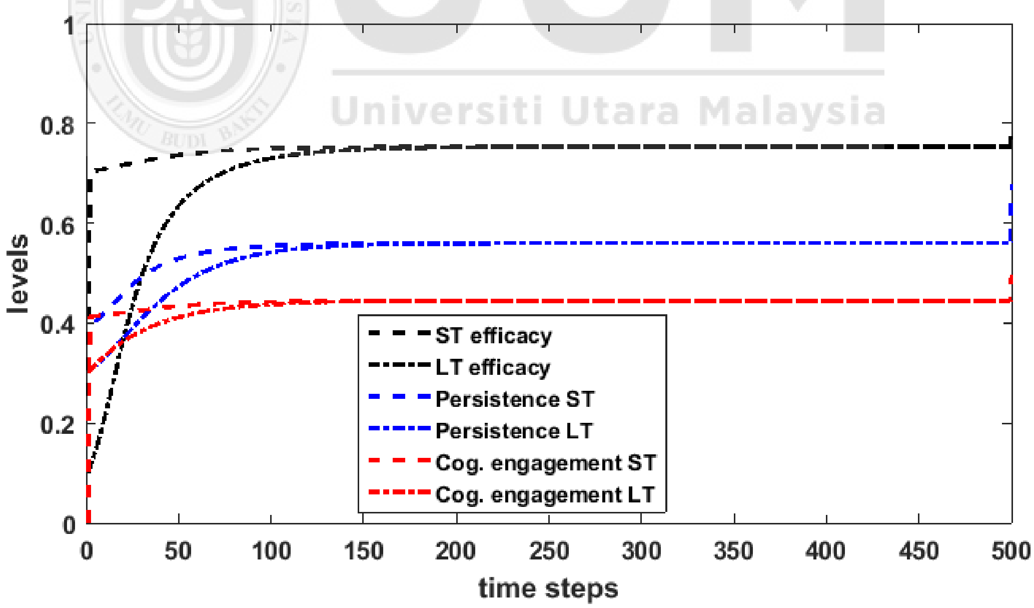

Figure 6.1. Stability points of selected factors in long term

Figure 6.1 shows the visual representation of the equilibria of self-efficacy, persistence and cognitive engagement. Stability occurs in each case when the short term value is equal to their respectively long terms. This condition can be observed through visual representation as in Figure 6.1. is in conformity with the first conclusion of the analysis above.

Analysis of the Equilibrium State

Considering the equilibrium

$$(Se=Le) \vee (Le=1) \vee (Le=0) \tag{6.4}$$
$$(Sp=Lp) \vee (Lp=1) \vee (Lp=0) \tag{6.5}$$
$$(Sf=Lf) \vee (Lf=1) \vee (Lf=0) \tag{6.6}$$

The next step of the analysis is to combine the three conditions (that is, $Se=Le$ or $Le=1$ or $Le=0$ in equation (6.4), $Sp=Lp$ or $Lp=1$ or $Lp=0$ in equation (6.5), and $Sf=Lf$ or $Lf=1$ or $Lf=0$ in equation (6.6)) into a new set of relationship, as in $(A \vee B \vee C) \wedge (D \vee E \vee F) \wedge (G \vee H \vee I)$ expression.

$$(Se=Le \vee Le=1 \vee Le=0) \wedge (Sp=Lp \vee Lp=1 \vee Lp=0) \wedge (Sf=Lf \vee Lf=1 \vee Lf=0) \tag{6.7}$$

This expression can be elaborated using *Distributive Law* as

$$(A \vee D \vee G) \wedge (A \vee D \vee H) \wedge (A \vee D \vee I) \wedge, \ldots, \wedge (C \vee F \vee I)$$

and this will result

$$(Se=Le \wedge Sp=Lp \wedge Sf=Lf) \vee \ldots\ldots. \vee (Le=0 \wedge Lp=0 \wedge Lf=0) \tag{6.8}$$

These equations later provide possible combinations of equilibria points to be further analysed. The full expansion of the equations will result in 3^3 (27) possible combinations.

Nevertheless, four equilibria cases are selected from the possible combinations and discussed.

Case #1: ***Lf* = 0**

From equation (4.9),

$$Sp = \omega_{sp1}.\mathrm{Be} + \omega_{sp1}.Se + \omega_{sp3}.Gp + \omega_{sp4.}.Lf$$

Where $Lf = 0$ this case is equivalent to:

$$Sp = \omega_{sp1}.Be + \omega_{sp2}.Se + \omega_{sp3}.Gp$$

Case #2: ***Le*=*1* ∧ *Lf* = *1* ∧ *Lp*=*1***

For this case, equations (4.5, 4.9, 4.7 and 4.13) provide a set of equilibria points through;

From equation (4.5),

$$Sk = \gamma_{sk}.Sk_{norm} + (1 - \gamma_{sk}).Lp$$

$$\gamma_{sk}.Sk_{norm} + (1 - \gamma_{sk})$$

Assume $\gamma_{sk} = 1$

$$Sk = Sk_{norm}$$

Assume $\gamma_{sk} = 0$

$$Sk = 1$$

From equation (4.9),

$$Sp = \omega_{sp1}.\mathrm{Be} + \omega_{sp1}.Se + \omega_{sp3}.Gp + \omega_{sp4.}.Lf$$

$$= \omega_{sp1}.Be + \omega_{sp2}.Se + \omega_{sp3}.Gp + \omega_{sp4}$$

From equation (4.7),

$$Ea = \alpha_{ea}.(\omega_{ea1}.Ei + (1 - \omega_{ea1}).Gp) + (1 - \alpha_{ea}).(\omega_{ea2}.Le + (1 - \omega_{ea2}).Mf)$$

$$= \alpha_{ea}.[\omega_{ea1}.Ei + (1-\omega_{ea1}).Gp] + (1- \alpha_{ea}).[\omega_{ea2} + (1-\omega_{ea2}).Mf]$$

From equation (4.13),

$$Pg = \omega_{pg1}.\mathrm{Sf} + \omega_{pg2}.Lp + \omega_{pg3}.Mf$$

$$= \omega_{pg1}.Sf + \omega_{pg2} + \omega_{pg3}.Mf$$

Case #3: *Se=Le*

Consider equation (4.13), the equilibria point is

$$Ea = \alpha_{ea}.[\omega_{ea1}.Ei + (1-\omega_{ea1}).Gp]+(1-\alpha_{ea}).[\omega_{ea2}.Se+(1-\omega_{ea2}).Mf]$$

Assuming $\omega_{ea1} = 1$, this case equivalent to:

$$Ea = \alpha_{ea}.[Ei]+(1-\alpha_{ea}).[\omega_{ea2}.Se+(1-\omega_{ea2}).Mf]$$

From this, if $\alpha_{ea} = 1$, thus

$$Ei = Ea$$

Case #4: *Lp = 0*

Equation (4.5) provides an equilibria point of;

$$Sk = \gamma_{sk}.Sk_{norm} + (1-\gamma_{sk}).Lp$$

$$= \gamma_{sk}.Sk_{norm}$$

Assuming $\gamma_{sk} = 1$,

thus $Sk = Sk_{norm}$

Effect of Stability Point

Based on equilibria point from equation 4.14, the effect of the stability point can be summarized as;

$$Sf = \lambda_{sf}.\left(\omega_{sf1}.Gp + \omega_{sf2}.Ea + \omega_{sf3}.Lp\right) + \left(1-\lambda_{sf}\right).Be$$

$$Sf = \lambda_{sf}.[\omega_{sf1}.Gp + \omega_{sf2}.Ea + \omega_{sf3}]+(1-\lambda_{sf}).Be$$

If $\lambda_{sf} = 1$ and ω_{sfi} are non-zero

$$Sf = \omega_{sf}[Gp + Ea + 1]$$

6.2.2 Verification of Stability through Value Substitution in Self-Efficacy Model

This verification method can be illustrated based on Figure 6.1 as follows.

Considering the state of long-term efficacy (*Lf*) using numerical representation at time *t*=300. The simulation results shows *Lf*(300) = 0.75288.

The accuracy of the simulation result can be confirmed by substituting the numerical values at the time *t* into the temporal equations to make comparisons.

For Example Equation (4.17)

$$Lf(t + \Delta t) = Lf(t) + \gamma_{lf}.\left(\mathrm{Sf}(t) - Lf(t)\right).\left(1 - Lf(t)\right).Lf(t).\Delta t$$

However, the equations expressing that a state of *Lf* is stabilized at time *t* are

$$Lf(t) = \left(\mathrm{Sf}(t)\right) \qquad (6.9)$$

⇨ For Lf*(300)=0.752885*

the equation for Lf(t) is in equation (4.14)

$$Sf(t) = \lambda_{sf}.\left(\omega_{sf1}.Gp(t) + \omega_{sf2}.Ea(t) + \omega_{sf3.}.Lp(t)\right) + \left(1 - \lambda_{sf}\right).Be(t)$$

$Gp(300) = 0.4835, Ea(300) = 0.4835, Lp(300) = 0.5604, Be(300) = 1.0000$
$\lambda_{sf} = 0.5,\ \omega_{sf1} = 0.33, \omega_{sf2} = 0.5, \omega_{sf3} = 0.5$

$$= 0.5[0.33 * 0.4890 + 0.33 * 0.4835 + 0.33 * 0.5604] + 0.5[1.0000]$$

⇨ $(0.752885 - 0.752926) < 10^{-3}$

The result above shows that the equation is fulfilled with the computed value of Sf(t) at time step 300 (0.752926) equilvalent the observed value of Lf(t) at time step 300

(0.752885) with negligible difference of less than 10^{-4}. This gives credence to the stability of the implemented model at time step 300.

6.2.3 Temporal Trace Language (TTL) for Self-Efficacy Agent Model

Known behaviours of constructs are stated as cases to be verified with TTL.

VP1: Basic efficacy contributed highly to long-term efficacy.

VP1 $\equiv \forall\gamma$:TRACE, t1, t2:TIME, n,v1,v2:REAL
[state(γ, t1)|= basic_efficacy(n) &
state(γ, t1)|= long_term_efficacy(v1) &
state(γ, t2)|= long_term_efficacy(v2) &
n $\geq$ 0.7 & t2= t1+D] $\Rightarrow$ [$\exists$t2:TIME > t1:TIME & v2 $\geq$ v1]

The final-efficacy belief one has through a task is highly determined by the initial efficacy he/she possesses at the start of the task which is defined by environmental and social factors such as experience and social support (Schunk, 1995).

VP2: Changes in Self-efficacy co-vary with similar changes in engagement

VP2 $\equiv \forall\gamma$:TRACE, $\forall$t1, t2:TIME $\forall$Q1, Q2, Q3, Q4,D:REAL
[state(γ, t1)|= has_value(self_efficacy, Q1) &
state(γ, t1)|= has_value(engagement, Q2) &
state(γ, t2)|= has_value(self_efficacy, Q3) &
state(γ, t2)|= has_value(engagement, Q4) &
Q1 $\geq$ 0.8 & Q3 $\geq$ Q1 & t2= t1+D] $\Rightarrow$ Q4 $\geq$ Q2

This analysis follows a number of studies such as in Ouweneel et al. (2013) where changes in self-efficacy levels over time were found to correspond with similar changes in engagement and performance. Those findings demonstrated individuals with a high confidence towards the tasks to be engage their repertoire of strategies and persist in their use than those doubting their capabilities. Moreover, this relationship found positive correlations between measures for perceived ability (self-efficacy) and indicators for cognitive engagement (Greene & Miller, 1996). The degree of self-efficacy in life purposes, visions and goals are revealed through persistence, perseverance and grit (De Pung, 2017).

VP3: Cognitive engagement develop in tandem with persistence

VP3≡ $\forall\gamma$:TRACE, $\forall$t1, t2:TIME $\forall$M1, M2, D:REAL
[state(γ, t1)|= persistence_level(M1) &
state(γ, t2)|= cognitive_engagement(M2) &
M1 $\geq$ 0.7 & t2= t1+D] $\Rightarrow$ M2 $\geq$ 0.5

Cognitive engagement is characterized by a psychological state in which efforts are exerted with persistence over a long period of time in order to achieve positive outcomes (Rotgans & Schmidt, 2011).

VP4: Uncontrolled anxiousness during task reduces Self-efficacy

VP4≡ $\forall\gamma$:TRACE, $\forall$t1, t2:TIME $\forall$V1, V2, V3, D:REAL
[state(γ, t1)|= anxiety(V1) &
state(γ, t1)|= self_efficacy(V2) &
state(γ, t2)|= anxiety(V3) &
state(γ, t2)|= self_efficacy(V4) &
V1 $\geq$ 0.6 & V3 $\geq$> V1 & t2= t1+D] $\Rightarrow$ V2 > V4

Anxiousness that may arise during task can be managed with the individual's coping ability. Though self-efficacy is a contributing factor to coping ability, however, when there is no enough of coping resources to stand the experienced demand in the task the individual becomes worried and which can lead to uncontrolled anxiousness. This in turn affects the efficacy information negatively hence reducing the overall self-efficacy belief in the long run (Barrows et al., 2013; Katalin Piniel & Csizér, 2013). Generalized self-efficacy is correlated with optimism and work satisfaction and negative coefficients were found for depression, stress, and anxiety (Schwarzer & Jerusalem, 1995).

6.3 Verification of Interview Motivation Agent Model

The mathematical analysis of the interview motivation agent model is presented in Section 6.3.1. The proving of the accuracy of the stability point through value substitution is presented in Section 6.3.2, while Section 6.3.3 presents the results of the TTL verification.

6.3.1 Mathematical Analyses of Motivation Model

To obtain possible equilibrium values for variables in the motivation model, the model is firstly described in a differential equation as in equations (6.10) and (6.11) derived from the temporal equations (4.33) and (4.34).

Equation (4.33)

$$Lm(t+\Delta t) = Lm(t) + \beta_{lm}.\begin{bmatrix} Pos\big(Sm(t) - Lm(t)\big).\big(1 - Lm(t)\big) \\ -Pos\big(-(Sm(t) - Lm(t) - \lambda_{ml})\big).Lm(t) \end{bmatrix}.\Delta t$$

$$\frac{dLm(t)}{dt} = \beta_{lm}.[\mathrm{Pos}\big((Sm - Lm).(1 - Lm)\big) - \mathrm{Pos}(-(Sm - Lm - \lambda_{ml}).Lm)] \qquad (6.10)$$

$$\mathrm{Pos}\big((Sm - Lm).(1 - Lm)\big)$$

$$-\mathrm{Pos}(-(Sm - Lm - \lambda_{ml}).Lm)$$

$$\big((Sm \ \le Lm \vee Lm = 1) \wedge (Sm \ \ge Lm - \lambda_{ml} \vee Lm = 0)\big)$$

This can logically be written into

$(Sm \leq Lm \wedge Sm \geq Lm - \lambda_{ml}) \vee (Sm \geq Lm - \lambda_{ml} \wedge Lm = 1) \vee (Lm = 1 \wedge Lm = 0)$

The latter case $(Lm = 1 \wedge Lm = 0)$ cannot exist, and as $0 \leq Sm \leq 1$, the other three cases are equivalent to $Lm = Lm$. Assumption could be made that $\lambda_{ml} = 0$.

Equation (4.34)

$Lp(t + \Delta t) = Lp(t) + \alpha_{lp}.\left[\left(Sp(t) - Lp(t)\right).Lp(t).\left(1 - Lp(t)\right)\right].\Delta t$

$$dLp(t)/dt = \alpha_{lp}.(\mathrm{Sp} - Lp).(1 - Lp).Lp \tag{6.11}$$

Next, the equations are identified describing

$\mathrm{d}Lp(t)/dt = 0$

Thus the following equations are found

Lp=*Sp* or *Lp*=*1* or *Lp*=*0*

Here *Sm* is the equilibrium value for short-term motivation, *Lm* for long-term motivation, λ_{ml} for decay, *Lp* for long-term persistence and *Sp* for short-term persistence.

The first set of conclusion, in this case, is that equilibrium can occur when short-term motivation equals long-term motivation and there is no decay. It also holds for where short-term persistence equals long-term persistence or long-term persistence is 1 or 0.

Cases are considered where formulae for calculating the equilibrium values are derived as follows:

Case #1: *Lm*=*Sm* and $\boldsymbol{\lambda_{ml} = 0}$

from equation (4.20),

$Lf = Lf.Lm$

From Equation (4.32)

$$Sm = \psi_{ms} . Ve + (1 - \psi_{ms}) . Ep$$

$$Lf = Lf . [\psi_{ms} . Ve + (1 - \psi_{ms}) . Ep]$$

Assume ψ_{ms}=0.5

$Lf = Lf$.(Ve + Ep)/2

Case #2: *Lp=1*

For this case, equations (4.23 and 4.29) provide a set of equilibria points through;

From Equation (4.23)

$$Sk = \gamma_{sk} . Sk_{norm} + (1 - \gamma_{sk}) . (\omega_{sk} . Pe + (1 - \omega_{sk}) . Lp)$$

$$Sk = \gamma_{sk} . Sk_{norm} + (1 - \gamma_{sk}) . (\omega_{sk} . Pe + (1 - \omega_{sk}))$$

Where $\gamma_{sk} = \omega_{sk} = 1$

$$Sk = Sk_{norm}$$

Equation (4.29)

$$Vc = \alpha_{vc} . Pd + (1 - \alpha_{vc}) . (Gl + Ep) . Lp$$

$$Vc = \alpha_{vc} . Pd + (1 - \alpha_{vc}) . (Gl + Ep)$$

Where $\alpha_{vc} = 1$

$$Vc = Pd$$

6.3.2 Verification of Stability through Value Substitution in Motivation Model

This verification method can be illustrated based on simulation result presented in Figure 6.2 as follows.

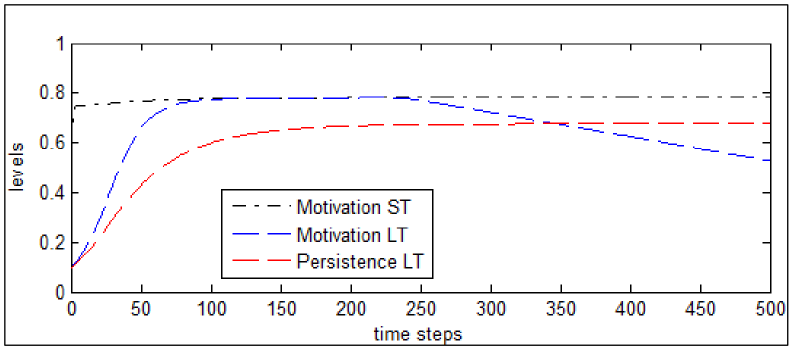

Figure 6.2. Stability point of Short-term and Long-term motivation

Considering the state of long-term motivation (*Lm*) using numerical representation at time t=150. The simulation results shows *Lm*(150) = 0.754712.

The accuracy of the simulation result can be confirmed by substituting the numerical values at the time *t* into the temporal equations to make comparisons.

From Equation (4.33)

$$Lm(t+\Delta t) = Lm(t) + \beta_{lm}.\begin{bmatrix} Pos\big(Sm(t) - Lm(t)\big).\big(1 - Lm(t)\big) \\ -Pos\big(-(Sm(t) - Lm(t) - \lambda_{ml})\big).Lm(t) \end{bmatrix}.\Delta t$$

However, the equations expressing that a state of *Lm* is stabilized at time *t* are

$$Lm(t) = \big(\mathrm{Sm}(t)\big) \qquad (6.12)$$

⇨ For *Lm(150)*= 0.754712

the equation for Sm(t) is

$$Sm(t) = \psi_{ms} \,.\, Ve(t) + (1 - \psi_{ms}) \,.\, Ep(t)$$

where

$Ve(150) = 0.68381$, $Ep(150) = 0.802422$, and $\psi_{ms} = 0.4$

$= 0.4[0.68381] + 0.6[0.802422]$

⇨ 0.754712 - 0.754977 < 10^{-3}.

The equation fulfilled the condition based on the result above a negligible error margin (less than 10^{-3}). This is clear evidence that the model as implemented indeed stabilizes at a point showing its accuracy and consistency.

6.3.3 Temporal Trace Language (TTL) for Motivation Agent Model

Some well-established cases in the literature are stated and verified with TTL.

VP5: Positive Personality Improves Persistence and Motivation

VP5≡ ∀γ:TRACE, t1, t2:TIME, v1,w1,w2:REAL
[state(γ, t1)|= personality(v1) &
  state(γ, t1)|=persistent(w1) &
  state(γ, t2)|=persistent(w2) &
   v1 > 0.7] ⇒ ∃t2:TIME > t1:TIME &
   [w2 > w1]

Individuals with positive personality have better possibilities to experience high persistence and to a large extent motivation levels (Bencsik et al., 2016; Pierce, 2009).

VP6: Difficulties to Maintain a Long-Term Motivation

VP6≡ ∀γ:TRACE, t1, t2, t3 :TIME, v1,w1,w1,w3:REAL
[state(γ, t1)|= personal_ability(v1) &
  state(γ, t1)|=long_term_motivation(w1) &
  state(γ, t2)|=long_term_motivation(w2) &
   v2 > 0.8] ⇒ ∃t3:TIME > t2:TIME &
   t2:TIME > t1:TIME [state(γ, t3)|= long_term_motivation (w3) & w1 > w3]

Regardless personality attributes, most of the interviewees motivational level can decline throughout time. This is in consistence with the findings that the environmental factors play roles to erode individual’s motivational levels (Gnambs & Hanfstingl, 2016).

VP7: Monotonic Decrease of Variable, v

VP7 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀Y1,Y2:REAL
[state(γ,t1)|= has_value(v, Y1) &
state(γ,t2)|= has_value(v, Y2) &
tb ≤ t1 ≤ te &
tb ≤ t2 ≤ te &
⇒ Y1 ≥ Y2

For all time points t1 and t2 between tb and te in trace γ if at t1 the value of v is y1 and at t2 the value of v is y2 and t1 < t2, then y1 ≥ y2

6.4 Verification of Interview Anxiety Agent Model

The interview agent model is verified by firstly performing the mathematical analysis in Section 6.4.1 followed by value substitution to check the accuracy of stability of the dynamics of Long term worry simulation in Section 6.4.2. Finally, Section 6.4.3 presents the results of the TTL verification of the interview agent model.

6.4.1 Mathematical Analyses of Interview Anxiety Model

To obtain possible equilibrium values for variables in the model of anxiety, the model is firstly described in a differential equation as in equations (6.13). The equation is derived from the temporal equation (4.43) of anxiety model.

Equation (4.43)

$$Lw(t+\Delta t) = Lw(t) + \alpha_{lw}.\begin{bmatrix} Pos\big(Sw(t) - Lw(t)\big).\big(1 - Lw(t)\big) - \\ Pos\Big(-\big(Sw(t) - Lw(t)\big)\Big).Lw(t) \end{bmatrix}.\Delta t$$

$$\frac{dLw(t)}{dt} = \alpha_{lw}.\left[\mathrm{Pos}\big((Sw - Lw).(1 - Lw)\big) - \mathrm{Pos}(-(Sw - Lw).Lw)\right] \tag{6.13}$$

$$\mathrm{Pos}\big((Sw - Lw).(1 - Lw)\big) - \mathrm{Pos}(-(Sw - Lw).Lw) = 0$$

$$\mathrm{Pos}\big((Sw - Lw).(1 - Lw)\big)$$

$$\mathrm{Pos}(-(Sw - Lw).Lw)$$

equivalence:

$$\big(Sw \ \leq Lw \vee Lw = 1) \wedge (Sw \ \geq Lw \vee Lw = 0)\big)$$

These two logical representations could be extended into

$$(Sw \ \leq Lw \wedge Sw \ \geq Lw \ )\vee(Sw \geq Lw \wedge Lw = 0)\vee(Sw \geq Lw \wedge Lw = 1)\vee(Lw = 0 \wedge Lw = 1)$$

The equation $(Lw = 0 \wedge Lw = 1)$is technically impossible, and as $0 \leq Sw \leq 1$ and $0 \leq Lw \leq 1$, these three cases could be considered ($Sw = Lw$, Sw=0 and Lw=*1*).

The first set of conclusion, in this case, is that equilibrium can only occur when the equations that involve short-term worry are equal to long-term worry.

Case #1: *Lw*=*Sw*

from equations (4.39)

$$Bw = \gamma_{bw} \,.(\beta_{bw}.Th + (1 - \beta_{bw}).Lw) + (1 - \gamma_{bw}).Sy$$

$$Bw = \gamma_{bw} \,.\big(\beta_{bw}.Th + (1 - \beta_{bw}).\big[(\varphi_{sw}.Bw + (1 - \varphi_{sw}).Th).\big(1 - (\psi_{sw}.Cr + (1 - \psi_{sw}).Ap)\big)\big]\big) + (1 - \gamma_{bw}).Sy$$

Where $\gamma_{bw} = \beta_{bw} = \varphi_{sw} = \psi_{sw} = 1$

⇨ $Bw = Th$

from equations (4.41)

$$Tc = Ap.(1 - Lw)$$

$$= Ap.\left(1-\left[(\varphi_{sw}.Bw+(1-\varphi_{sw}).Th).\left(1-(\psi_{sw}.Cr+(1-\psi_{sw}).Ap)\right)\right]\right)$$

Where $\varphi_{sw} = \psi_{sw} = 1$

$Tc = Ap\ [1-(Bw\ .\ (1-Cr))]$

6.4.2 Verification through Value Substitution from Interview Anxiety Model Simulation

Figure 6.3 showing the simulation result of interview agent model stabilization is used to illustrate this verification method as follows.

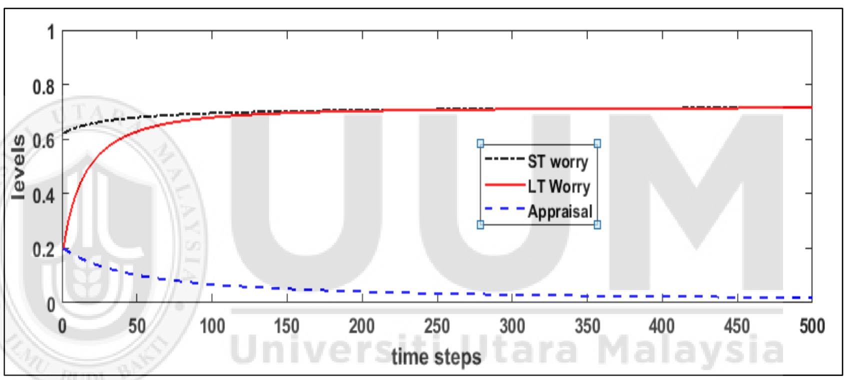

Figure 6.3 Simulation result of anxiety stability

Considering the state of long-term worry (*Lw*) using numerical representation at time *t*=300. The simulation results shows *Lw*(300) = 0.70965.

The accuracy of the simulation result can be confirmed by substituting the numerical values at the time *t* into the temporal equations to make comparisons.

From Equation (4.43)

$$Lw(t+\Delta t) = Lw(t) + \alpha_{lw}.\begin{bmatrix} Pos\big(Sw(t)-Lw(t)\big).\big(1-Lw(t)\big) - \\ Pos\Big(-\big(Sw(t)-Lw(t)\big)\Big).Lw(t) \end{bmatrix}.\Delta t$$

However, the equations expressing that a state of *Lw* is stabilized at time *t* are

$Lw(t) = \left(\mathrm{Sw}(t)\right)$ (6.14)

⇨ For *Lm(300)*= 0.70965.

the equation (4.40) for Sw(t) is

$$Sw(t) = \left(\varphi_{sw}.Bw(t) + (1 - \varphi_{sw}).Th(t)\right) * \left(1 - \begin{pmatrix} \psi_{sw}.Cr(t) \\ +(1 - \psi_{sw}).Ap(t) \end{pmatrix}\right)$$

where

$Bw(300) = 0.68381, Ep(350) = \ 0.802422,$ and $\psi_{ms} = 0.4$

$= 0.4[0.68381] + 0.6[0.802422]$

⇨ 0.754712 - 0.754977 ≈ 0

The negligible error margin of less than 10^{-3} in the presented result above shows that the equation is fulfilling. This is a proof that the model as implemented indeed stabilizes at a point showing its accuracy and consistency with expectation.

6.4.3 Temporal Trace Language (TTL) for Interview Agent Model

Some simulated cases in anxiety model are verified with TTL and discussed in relation to established studies in literature.

VP8: An assertive personality reduces anxiety in an unfavourable interview environment

VP8≡ ∀γ:TRACE, t1, t2, t3 :TIME, v1,v2,w1,w1,h1, h2:REAL

[state(γ, t1)|=personality(v1) &

state(γ, t1)|=long_term_worry(h1) &

v1 ≥ 0.8] ⇒ t2:TIME > t1:TIME

[state(γ, t2)|= long_term_worry(h2) & h1 > h2]

The strength of one's character has ability to change an expected negative situation into a manageable one. For example, in a negative task situation such as job interview, an interviewer with high positive assertive personality can manage the worry condition hence reducing his/her anxiety level (Skodol et al., 2014).

VP9: Threat increases when situation demand outgrows coping resources

VP9 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀Y1,Y2, V1,V2, W1,W2:REAL
[state(γ,t1)|= threat(Y1) &
state(γ,t1)|= situation_demand(V1) &
state(γ,t1)|= coping(W1) &
state(γ,t2)|= threat(Y2) &
state(γ,t2)|= situation_demand(V2) &
state(γ,t2)|= coping(W2) &
V2 ≥ V1 & V2 ≥ W2] ⇒ ∃t2:TIME > t1:TIME & Y2 > Y1]

Demanding situation increases task threat, however coping resources reduces threat. The building of worry begins with perceived threat which is measured from the difference between situation demand and coping (Fonseca et al., 2014).

VP10: Personal appraisal has a negative correlation to worry and positive about thought control.

VP10 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀D1, D2, F1,H1,H2, d:REAL
[state(γ,t1)|= personal_appraisal(F1) &
state(γ,t1)|= long_term_worrry(H1) &
state(γ,t2)|= thought_control(D1) &
state(γ,t2)|= long_term_worry(H2)&
state(γ,t2)|= thought_control(D2) &
F1 > 0.8 & t2 ≥t1 +d] ⇒ D2 > D1 & H1 > H2

A high value of *personal appraisal* (positive) implies a low value in the belief of the use of worry as a coping strategy. This means that such an individual will be in a better position to manage his thought process (positive thought control) (Wells, 2005).

6.5 Verification of Integrated Model

The integrated model is mathematically analysed in Section 6.5.1. Proof of the accuracy of the stability points of the dynamic equation in the model is presented in Section 6.5.2 while the automatic verification (TTL) of established cases in the integrated model is presented in Section 6.5.3.

6.5.1 Mathematical Analyses of the Integrated Model

The integrated model consists of several temporal equations, which can be explored by analysing the equilibrium points of the model. The equations as re-stated below are used to derive the equilibria states of 3 temporal equations representing the 3 key observed outputs from the integrated model (self-efficacy, motivation and anxiety). State equations (6.15), (6.16) and (6.17) are therefore derived from temporal equations of the constituent agent models (i.e., Long-term motivation, Long-term worry (anxiety) and Long-term efficacy).

Equation (4.33) for Long-term motivation

$$Lm(t+\Delta t) = Lm(t) + \alpha_{lw}.\begin{bmatrix} Pos\big(Sm(t) - Lm(t)\big).\big(1 - Lm(t)\big) - \\ Pos\big(-(Sm(t) - Lm(t) - \lambda)\big).Lm(t) \end{bmatrix}.\Delta t$$

$$\frac{dLm(t)}{dt} = \beta_{lm}.[\mathrm{Pos}\big((Sm - Lm).(1 - Lm)\big) - \mathrm{Pos}(-(Sm - Lm - \lambda_{ml}).Lm)] \qquad (6.15)$$

$$\text{Pos}\big((Sm - Lm).(1 - Lm)\big)$$

$$-\text{Pos}(-(Sm - Lm - \lambda_{ml}).Lm)$$

$$\big(Sm \ \leq Lm \vee Lm = 1\big) \wedge \big(Sm \ \geq Lm - \lambda_{ml} \vee Lm = 0\big)\big)$$

This can logically be written into

$$(Sm \ \leq Lm \wedge Sm \ \geq Lm - \lambda_{ml}\ ) \ \vee (Sm \ \geq Lm - \lambda_{ml} \wedge Lm = 1) \vee (Lm = 1 \wedge Lm = 0)$$

The latter case $(Lm = 1 \wedge Lm = 0)$ cannot exist, and as $0 \ \leq Sm \leq 1$, the other three cases are equivalent to $Lm = Lm$. Assumption could be made that $\lambda_{ml} = 0$.

Equation (4.43) for Long-term Anxiety

$$Lw(t + \Delta t) = Lw(t) + \ \alpha_{lw}. \begin{bmatrix} Pos\big(Sw(t) - Lw(t)\big).\big(1 - Lw(t)\big) - \\ Pos\Big(-\big(Sw(t) - Lw(t)\big)\Big).Lw(t) \end{bmatrix}.\Delta t$$

$$\frac{dLw(t)}{dt} = \alpha_{lw}.\big[\text{Pos}\big((Sw - Lw).(1 - Lw)\big) - \text{Pos}(-(Sw - Lw).Lw)\big] \qquad (6.16)$$

$$\text{Pos}\big((Sw - Lw).(1 - Lw)\big) - \text{Pos}(-(Sw - Lw).Lw) = 0$$

$$\text{Pos}\big((Sw - Lw).(1 - Lw)\big)$$

$$\text{Pos}(-(Sw - Lw).Lw)$$

equivalence:

$$\big(Sw \ \leq Lw \vee Lw = 1\big) \wedge \big(Sw \ \geq Lw \vee Lw = 0\big)\big)$$

These two logical representations could be extended into

$$(Sw \ \leq Lw \wedge Sw \ \geq Lw\ ) \vee (Sw \geq Lw \wedge Lw = 0) \vee (Sw \geq Lw \wedge Lw = 1) \vee (Lw = 0 \wedge Lw = 1)$$

The equation $(Lw = 0 \wedge Lw = 1)$is technically impossible, and as $0 \leq Sw \leq 1$ and $0 \leq Lw \leq 1$, these three cases could be considered ($Sw = Lw$, Sw=0 and Lw=*1*).

Equation (4.17) for Long-term Self-efficacy

Equation (4.17)

$Lf(t + \Delta t) = Lf(t) + \gamma_{lf}.\left(Sf(t) - Lf(t)\right).Lf(t).\left(1 - Lf(t)\right).\Delta t$

$$dLf(t)/dt = \gamma_{lf}.(\mathrm{Sf} - Lf).(1 - Lf).Lf \qquad (6.17)$$

the equations are further identified as follows where change is not expected at equilibrium,

$$dLm(t)/dt = 0$$
$$dLw(t)/dt = 0$$
$$dLf(t)/dt = 0$$

Where all temporal parameters are assumed to be equal to 1 then the equations are;

$$(Sm=Lm) \vee (Lm = 1) \vee (Lm = 0) \qquad (6.18)$$

$$(Sw=Lw) \vee (Lw = 1) \vee (Lw = 0) \qquad (6.19)$$

$$(Sf=Lf) \vee (Lf = 1) \vee (Lf = 0) \qquad (6.20)$$

The conclusion that can firstly be reached in this is situation is where the equilibria points can only occur when *Sm=Lm* or *Lm=1* or *Lm*=0 in equation (6.18), *Sw*=*Lw* or *Lw*=1 or *Lw*=0 in equation (6.19), and *Sf*=*Lf* or *Lf*=1 or *Lf*=0 in equation (6.20).

Analysis of Equilibrium State

Considering the equilibrium state equations stated above, the next step of the analysis is to combine the three conditions (that is, *Sm=Lm* or *Lm=1* or *Lm*=0 in equation (6.18), *Sw*=*Lw* or *Lw*=1 or *Lw*=0 in equation (6.19), and *Sf*=*Lf* or *Lf*=1 or *Lf*=0 in equation (6.20)) into a new set of relationship, as in $(A \vee B \vee C) \wedge (D \vee E \vee F) \wedge (G \vee H \vee I)$ expression.

$$(Sm=Lm \vee Lm=1 \vee Lm=0) \wedge (Sw=Lw \vee Lw=1 \vee Lw=0) \wedge (Sf=Lf \vee Lf=1 \vee Lf=0) \qquad (6.21)$$

This expression can be elaborated using *Distributive Law* as

$$(A \vee D \vee G) \wedge (A \vee D \vee H) \wedge (A \vee D \vee I) \wedge, \ldots, \wedge (C \vee F \vee I)$$

and this will result into

$$(Sm=Lm \wedge Sw=Lw \wedge Sf = Lf) \vee \ldots\ldots. \vee (Lm= 0 \wedge Lw=0 \wedge Lf=0) \tag{6.22}$$

These equations later provide possible combinations of equilibria points to be further analysed. The full expansion of the equations will result in 3^3 (27) possible combinations. However, four equilibria cases are selected from the possible combinations and analysed as follows.

Case #1: *Sm=Lm*, *Sw=Lw*, *Sf=Lf*

Consider equations (4.49).

$$Cr = \omega_{cr1}.Pe + \omega_{cr2}.Ss + \omega_{cr3}.Lf + \omega_{cr4}.Pa$$

$$Cr = \omega_{cr1}.Pe + \omega_{cr2}.Ss + \omega_{cr3}.Sf + \omega_{cr4}.Pa$$

Consider equations (4.51).

$$As(t) = Lw(t).\big(1 - Be(t)\big)$$

$$As = Sw.(1 - Be)$$

Consider equations (4.52).

$$Sp(t) = \big(\gamma_{sp}\,.Lf + \big(1 - \gamma_{sp}\big).Sm\big).Gl$$

$$Sp = \big(\gamma_{sp}\,.Lf + \big(1 - \gamma_{sp}\big).Lm\big).Gl$$

$where\ \gamma_{sp=}0.5$

$$Sp = (0.5\,.Lf + 0.5.Lm).Gl$$

$$Sp = \tfrac{1}{2}GL(Lf + Lm)$$

Case #2: ***Lm= 0 ∧ Lw=0 ∧ Lf=0***

Substitute *Lm* and *Lf* in case #1 above

$$Sp = \frac{1}{2}GL(Lf + Lm)$$

⇨ $Sp = \frac{1}{2}GL$

Case #3: ***Lw=1 ∧ Lf = 1 ∧ Lm=1***

Substitute *Lm* and *Lf* in case #1 above

$$Sp = \frac{1}{2}GL(Lf + Lm)$$

⇨ $Sp = GL$

6.5.2 Verification of Stability through Value Substitutions of Lw, Lm, and Lf in the Integrated Model

The stability of the temporal factors in the integrated model shown in Figure 6.4 is used to illustrate this verification method as follows.

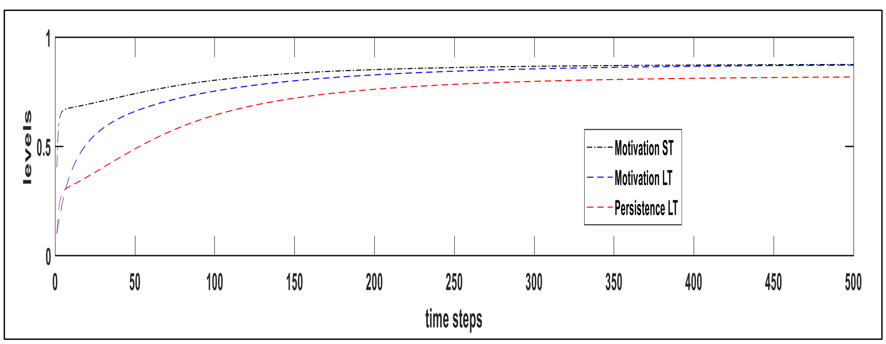

Figure 6.4. Simulation results of the integrated model stability points

Considering the high states of long-term efficacy (*Lf*), Long-term memory (*Lm*) and Long-term worry (*Lw*) using numerical representation at time *t*=400. The simulation results shows *Lf*(400) = 0. 76214, *Lm*(400) = 0.82046, *Lw*(400) = 0.74231.

The accuracy of the simulation results can be confirmed by substituting the numerical values at the time *t* into the temporal equations to make comparisons.

$$Lm(t+\Delta t) = Lm(t) + \alpha_{lm}.\begin{bmatrix} Pos\big(Sm(t) - Lm(t)\big).\big(1 - Lm(t)\big) - \\ Pos\big(-(Sm(t) - Lm(t) - \lambda)\big).Lm(t) \end{bmatrix}.\Delta t$$

$$Lw(t+\Delta t) = Lw(t) + \alpha_{lw}.\begin{bmatrix} Pos\big(Sw(t) - Lw(t)\big).\big(1 - Lw(t)\big) - \\ Pos\left(-\big(Sw(t) - Lw(t)\big)\right).Lw(t) \end{bmatrix}.\Delta t$$

$$Lf(t+\Delta t) = Lf(t) + \gamma_{lf}.\big(Sf(t) - Lf(t)\big).Lf(t).\big(1 - Lf(t)\big).\Delta t$$

the equations expressing that each of the states in the above equation (i.e. *Lw, Lm, Lf*) is stabilized at time *t* are

$$Lm(t) = \big(Sm(t)\big) \tag{6.23}$$

$$Lw(t) = \big(Sw(t)\big) \tag{6.24}$$

$$Lf(t) = \big(Sf(t)\big) \tag{6.25}$$

⇨ For *Lm(400)*= 0.82046

the equation for Sm(t) is

$$Sm(t) = \psi_{sm}.Ve(t) + (1 - \psi_{sm}).Ep(t) \tag{6.26}$$

Where

$Ve(400) = 0.78927, Ep(400) = 0.86101, and\ \psi_{sm} = 0.5$

$= (0.5)\,.\,0.78927 + (0.5)\,.\,0.86101$

⇨ 0.82046 ≈ 0.82514

The result above shows that the equation is fulfilled with a negligible error margin (less than 10^{-2}). The result of the motivation as implemented is in tandem with the expected behaviour.

⇨ For *Lf(350)*= 0. 76214

the equation for Sf(t) is

$$Sf(t) = \psi_{sf}.\left(\omega_{sf1}.Gp(t) + \omega_{sf2}.Ea(t) + \omega_{sf3}.LpE(t)\right) + \left(1 - \psi_{sf}\right).Be(t) \quad (6.27)$$

Where

$Gp(350) = 0.78222, Ea(400) = 0.617516, LpE(400) = 0.78407, Be(400) = 0.8100$

$\psi_{sf} = 0.5, \omega_{sf1} = \omega_{sf2} = \omega_{sf3} = 0.33$

$= 0.5 * 0.33(0.78222 + 0.617516 + 0.78407) + 0.5 * 0.81000$

⇨ 0.76214 ≈ 0.76533

With a negligible error margin of less than 10^{-2} the results above proves the fulfilling of the temporal equation. The result of the self-efficacy as implemented in the model agrees with the expected behaviour and therefore proven.

⇨ For *Lw(400)*= 0.74231

the equation for Sw(t) is

$$Sw(t) = \left(\varphi_{sw}.Bw(t) + (1 - \varphi_{sw}).Th(t)\right) * \left(1 - \begin{pmatrix} \psi_{sw}.Cr(t) + \\ (1 - \psi_{sw}).Ap(t) \end{pmatrix}\right) \quad (6.28)$$

Where

$Bw(400) = 0.80841, Th(400) = 0.75340, Cr(400) = 0.06987, Ap(400) = 0.02564$

$\psi_{sw} = 0.5, \varphi_{sw} = 0.5$

$= (0.5 * 0.80841 + 0.5 * 0.75340) * \left(1 - (0.5 * 0.06987 + 0.5 * 0.02564)\right)$

⇨ 0.74231 ≈ 0.74361

The result shows an error margin of less than 10^{-3} . This proves the fulfilling of the temporal equation of anxiety in the integrated model. The result of anxiety as implemented in the model equally agrees with the expected behaviour.

The equilibrium of the three fundamental temporal equations that serves as outputs to determine the behaviour of the model proven by value substitution above, with only dismal error, it is correct to say that the integrated model actually achieve stability and behaving as expected (Treur, 2016d).

6.5.3 Temporal Trace Language (TTL) for Integrated Model

In order to verify whether the cognitive agent based model indeed generates results that adhere to psychological literature, a set of properties are identified from literature relating to the domain. The identified properties are then specified by Temporal Trace Language (TTL). Some cases are analysed are as follows

VP11: Interviewer disposition influences behaviour of interviewee high in trait anxiety and low personality.

VP11 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀ D1, F1, H1, V1, d:REAL
[state(γ,t1)|= interviewer_disposition(V1) &
state(γ,t1)|= personal_trait(H1) &
state(γ,t1)|= personality(D1) &
state(γ,t2)|= long_term_worry(F1)&
V1 < 0.3 & D1 > 0.8 & H1 > 0.8 & t2 ≥t1 +d] ⇒ F1 > 0.6

In an interview situation, the main threat stimulus is the interviewer (audience) conceptualized in this model as interviewer disposition (perceived relatedness) and the primary threatening outcome is the interviewer's negative evaluation (Rapee & Heimberg, 1997). Therefore the mode, personality, and subduing character displayed by the interviewer during the session have a tendency of directing the interviewee behaviour especially if not strong in personality and trait (Huffcutt et al., 2011). Therefore a low sense of perceived relatedness due to interviewer's negative attitudes will increase the interviewee anxiety.

VP12: Perceived sense of efficacy plays a key role in the arousal of anxiety.

VP12 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀ V1, F1, F2, d:REAL
[state(γ,t1)|= perceived_efficacy(V1) &
state(γ,t1)|= anxiety(F1) &
state(γ,t2)|= anxiety(F2)&
V1 < 0.2 & t2 ≥t1 +d] ⇒ F2 > F1

The social cognitive theory asserts that one's perceived sense of self-efficacy plays a key role in anxiety arousal (Wood & Bandura, 2013). An individual experiences anxiety when they are relatively doubtful of their capabilities (low self-efficacy) to manage potentially detrimental events (Bandura, 1997). Consistently, two main references in this area show that low levels of self-efficacy are usually accompanied by high levels of anxiety (Hanton & Connaughton, 2002; Tahmassian & Moghadam, 2011).

VP13: Threat affects motivation and anxiety

VP13 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀ V1, F1, F2, D1, D2, d:REAL
[state(γ,t1)|= threat(V1) &
state(γ,t1)|= anxiety(F1) &
state(γ,t1)|= motivation(D1) &
state(γ,t2)|= anxiety(F2)&
state(γ,t2)|= motivation(D2)&
V1 > 0.7 & t2 ≥t1 +d] ⇒ F2 > F1 & D2 < D1

The threat is a psychological or a mental state in which an individual perceives himself/herself as being unable to cope with a task (Fonseca et al., 2014). This happens when coping resources is not enough to manage the task demand. This, therefore, can be linked to losing of fate in personal competence which can lead to a state of worry (Hirsch & Mathews, 2012) and fail in the efforts and perseverance which are the key ingredients of motivation (Lunenburg, 2011).

VP14: Persistence in task mediate the complementary effects of motivation and self-efficacy

VP15 ≡ ∀γ: TRACE, ∀t1, t2:TIME, ∀X1,X2,X3:REAL
[state(γ,t1)|= persistence(v, X1) &
 state(γ,t2)|= self_efficacy(v, X2) &
 state(γ,t2)|= motivation(v, X3) &
 X1> 0.8 tb ≤ t1 ≤ te & tb ≤ t2 ≤ te]
 ⇒ X2 ≥ 0.5 & X3 ≥ 0.5

Self-efficacy improves individual's motivation to undertake projects and persists in the pursuit of his/her goals, in the face of setbacks and difficulties that may periodically test his/her drive (Bénabou & TiroleSource, 2002). High sense of self-efficacy therefore enhances one's strength to persevere and persistence is an instrument to improving motivation in a task (Lunenburg, 2011; Schunk, 1995).

6.6 Validation of the Integrated Cognitive Agent Model

This section discusses the validation of the integrated cognitive agent model formalized and simulated in the previous chapters. The design and procedures to guide the experiment is discussed and concluded with data analysis.

6.6.1 Experimental Details

This experimental study is aimed to validate the designed integrated agent of interviewee mental state. The designed model is expected to behave in a similar manner to human agents it is intended to mimic using three interplaying constructs of self-efficacy, motivation and anxiety during interviews. This type of black-box validation procedure is adopted where the focus is in a simple comparison of the output from a simulated model with that of phenomenon its intended to mimic (Majid et al., 2009; Treur, 2016d). Standardized instruments were adapted to measure relevant factors for the quantitative research approach adopted for the experiment. The research design that is used in this evaluation is experimental. A multivariate statistical method called Hotelling's T^2 distribution is the tool used to analyse the data and test the hypothesis (Manly & Alberto, 2016; Sparks, 2014). The two multivariate normal populations are the human experiment outputs and simulation outputs; each having three constructs, anxiety, self-efficacy and motivation. The hypotheses to be tested in this case are restated in the analysis section.

The thirty-six final level undergraduate recruited for the experiment were selected randomly through a purposive approach of choosing the higher institution (Kaduna Polytechnic) to use. The multi-stage sampling has been used for volunteered students from three department chosen randomly. The lecturers that participated as interviewers were selected based on their background in interviewing processes.

The experiment was conducted in three phase which are 1) pre-interview, 2) interview and 3) post-interview phases. Table 6.2 describes the pre-phase and post-phase and all factors measured involved.

Table 6.1

Measuring Factors According to Experiment Phases

Pre-interview	Post-interview
1. Prior experience (Mastery)	1. Task demand
2. Vicarious experience	2. Verbal persuasion
3. Personal autonomy	3. Interviewer disposition (relatedness)
4. Personality (assertiveness)	4. State anxiety
5. Social support	5. Motivation
6. Trait (anxiety)	6. Self-efficacy

Measuring Instruments

Measurements of each of the factors were obtained from the instruments accordingly. The responded instruments were matched using the unique students' registration number provided on both the pre and post interview questionnaires. The details of instruments for the measurements of the factors are states below.

(i) *Personal autonomy:* This is measured by the Index of Autonomous Function (IAF) scale. IAF has been validated in a number of studies (Weinstein et al., 2012). IAF is a 15-item and 5-point Likert-type scale (1=not at all true to 5=completely true) segmented into 3 parts (Authorship/self-congruence, Susceptibility to control and Interest-taking) of five items each. The five items of susceptible to control are to be reversed scored. Sample items include: "I strongly identify with the things that I do", "I do a lot of things to avoid feeling ashamed" and "I often reflect on why I react the way I do". Internal reliability was high (α = .82).

(ii) *Assertiveness:* A 19-item and 6-scale Short Form of Simple Rathus Assertiveness Scale (SRAS-SF) is used to measure assertiveness. The scale is 6 = very much like me to 1 = very unlike me. SRAS=SF has been validated (Jenerette & Dixon, 2010) with internal reliability of (α = .81). Sample items are ―Most people stand up for themselves more than I do" and ―There are times when I look for a good strong argument".

(iii) *Social Support:* This is measured by Multidimensional Scale of Perceived Social Support (MSPSS) (Zimet et al., 1988). MSPSS is a 12-item and 7-point scale (1=very strongly disagree to 7=very strongly agree). Sample items include: ―There is a special person who is around when I am in need", and ―My family is willing to help me make decisions". The Cronbach's coefficient alpha, a measure of the internal reliability of the instrument is (α = .88).

(iv) *Trait Anxiety:* This is measured by Trait Anxiety subscale of the State-Trait Anxiety Scale (Spielberger et al., 1977). It is a 20-item instrument of 4-point Likert scale (1=Almost Never, 2=Sometimes, 3=Often, 4=Almost Always). Statements such as ―I feel nervous and restless", ―I feel like a failure" and ―I have disturbing thoughts" are sample items for the scale. Some of the questions are reversed scored due to the opposite nature of the statements. The reliability coefficient is (α = .87).

(v) *Relatedness:* Interviewer disposition (relatedness) is measured with Need for Relatedness Scale (Richer & Vallerand, 1998) because it measures general feelings of belonging or social connection. This scale was developed to assess relatedness in the workplace but was slightly modified for the relatedness of the interviewee to the interviewer owing to interviewer disposition. The instrument is a 10-item of a 7-

point scale (1 = Do not agree at all; to 7= very strongly agree). The lead statement to the question was amended to reflect the interview situation to become “In my relationship with the interviewer during the interview process, I feel ...”. The questions are now like “I feel supported”, “I feel closed to him” and “I feel safe”. The reliability coefficient of the scale is (α = .70) in studies such as (Sevari, 2017).

(vi) *Motivation:* The construct was measured with Short Form of Questionnaire on Current Motivation (QCM). The instrument is a 12-item of 7-Likert scale (1= Very Strongly disagree to 7= Very Strongly agree). Most of the statements were changed to reflect the interview situation as in the sample item such as “I probably managed to do the interview” and “I feel under pressure to do the interview well”. The instrument has been validated (see, Freund, Kuhn, & Holling, 2011) with internal reliability coefficient is (α = .82).

(vii) *Anxiety:* This is measured by State Anxiety subscale of the State-Trait Anxiety Scale (Spielberger, 1977). It is a 20-item scale of 4-point Likert scale (1=Almost Never, 2=Sometimes, 3=Often, 4=Almost Always). Statements such as “I feel I am tense” and “I am presently worrying over possible misfortune” are sample items for the scale. Some of the questions are reversed scored due to the opposite nature of the statements. The reliability coefficient is (α = .87).

(viii) *Self-Efficacy:* Generalized self-efficacy scale (GSE) is used to measure self-efficacy. GSE is a 10-item of a 4-point scale (1= Not at all true, 2= Hardly true, 3= Moderately true, and 4= Exactly true) used to measure how the respondents believe in their ability to carry out each of the statements. Some of the statements were however changed to reflect the specific nature of interview task. For instance, the statement that ―if someone opposes me, I can find the means and ways to get what I want" was changed to ―even when I am opposed during the interview, I can find the means and ways to get my response out". Also, the statement that ―I can solve most problems if I invest the necessary effort" was changed to ―I can answer all questions if I invest the necessary effort". GSE has been validated in several studies (Hajloo, 2014; Schwarzer & Jerusalem, 1995) with internal reliability Cronbach's alphas between .76 and .90. GSE is correlated to emotion, optimism, work satisfaction and negative coefficients were found for depression, stress, health complaints, burnout, and anxiety.

Data Computation

The data computations for each of the respondent on individual factors are explained below.

(i) Prior experience: weight associated with each of the options of the 5 multiple choice question represents the value of the experience. While ―No Experience" is assigned 0, ―Extensive Experience" is assigned 4. The final input value is obtained by dividing the selected option value by 4.

(ii) Vicarious experience: measured by associated values to 5 options of the single vicarious experience question. ―Never" is allocated 0 while ―4 times and above" is allocated 4. The final input value is obtained by dividing the selected option value by 4.

(iii) Personal Autonomy: the instrument is scored by reversing items 6 to 10 so that the higher scores on every item will indicate a higher level of autonomy.

This is done by subtracting the item's response from 6 and uses that as the item score. The total score on Autonomy for a respondent is calculated by averaging the item scores for the 15 items in the scale.

(iv) Personality (Assertiveness): 11 items out of 19 that are asterisk (1, 2, 4, 7, 8, 9, 10, 11, 12, 15, 17) are reverse scored by subtracting from 7. The obtained values are summed to serve as the assertiveness score for the respondent. The total obtainable score is 114.

(v) Social support: all the 12 items are summed directly to represent each respondent's social support value. The total obtainable score is 12 x 7 = 84.

(vi) Trait: the 20-item instrument has 9 items negative scores (1, 3, 6, 7, 10, 13, 14, 16, and 19). Scores are subtracted from 5. The valued is obtained by summing up respondent's scores. Total obtainable value is 20 x 4 = 80.

(vii) Task demand: the five options on the task demand question is allocated values in order of magnitude. ―Not demanding" is allocated 0 while ―Highly demanding" is allocated 5.

(viii) Verbal persuasion: the 4 options question is valued according to the magnitude from 0 (Not at all) to 3(Very much).

(ix) Relatedness: all the items in the 10-item questionnaire are scored directly. The sum of the items represents the perceived relatedness or the interviewer disposition of the respondent. The overall score obtainable is 70.

(x) Anxiety: this is measured by reversing 10 items (1, 2, 5, 8, 10, 11, 15, 16, 19, and 20) out of the 20 items of state anxiety instrument. Scores are negated by subtracting from 5. The summed response is the trait anxiety of the respondent. Total obtainable value is 80.

(xi) Motivation: item 2 is reversed by subtracting its score from 7. All other items of the 12-item instrument are direct. Summed scores of the items represent the motivation of the respondent. The total obtainable value is 84.

(xii) Self-efficacy: The total score is calculated by finding the sum of all items. The total score ranges between 10 and 40, with a higher score indicating more self-efficacy.

The data obtained from the questionnaire and interpretations in relation to the validation of the formal cognitive agent model of interviewee mental state are presented in the data analyses section that follows.

6.6.2 Data Analyses

The data obtained from the demography of the respondents shows that all the respondents except two are above 22 years of age. The two exceptions are 21 and 22 years of age. The respondents are almost equal in terms of gender. There are 19 male and 17 female who made up the final 36 whose data were used. The pie chart in Figure 6.5 shows the percentage participation according to gender.

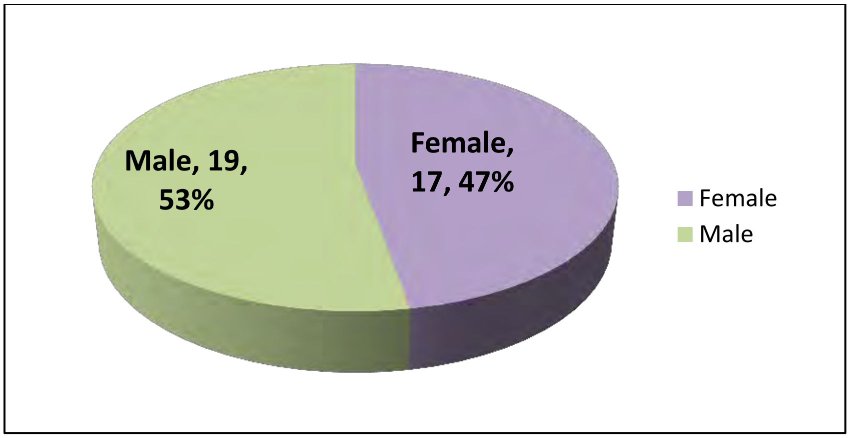

Figure 6.5. Respondents' gender representation

The chart in Figure 6.2 shows that 53% representing 19 respondents are male while 47% representing 17 respondents are female. This indicates a fair representation of respondents by gender.

The direct data coded from the response of both the pre-interview and post-interview questionnaires are used in detail statistical analyses presented.

The statistical tool used is Hotelling's T^2 distribution, good for testing the multivariate hypothesis (Manly & Alberto, 2016; Sparks, 2014). When there is an interest in comparing only two populations, multiple t-tests may be considered, but such analyses can result in an unacceptably high Type I error rate in our case. To avoid this problem, a single hypothesis testing procedure (omnibus test) based on the analysis of variation among group means and variation of units within groups may be conducted. This omnibus test of two group means is conducted using the Hotelling's T^2 distribution.

From the data using the SPSS, the results were obtained as follows:

Hypothesis

H_0: The human and simulated model outputs of anxiety, self-efficacy and motivation are not significantly different.

H_1: The human and simulated model outputs of anxiety, self-efficacy and motivation are significantly different.

Level of Significance

$\alpha=0.05$

Decision Criterion

Reject the null hypothesis if $p<0.05$

Computations

The computed results as carried out by the SPSS are given in the following tables and figures:

Table 6.2

Descriptive Statistics

Variables	Output	N	Mean	Std. Deviation
Anxiety	Human Output	36	0.3217	0.1644
	Simulation Output	36	0.2769	0.2293
	Total	72	0.2993	0.1993
Self-efficacy	Human Output	36	0.3664	0.0880
	Simulation Output	36	0.3460	0.1556
	Total	72	0.3560	0.1259
Motivation	Human Output	36	0.5661	0.1959
	Simulation Output	36	0.5475	0.2020
	Total	72	0.5568	0.1978

The descriptive statistics above show the means and standard deviations for anxiety, self-efficacy and motivation for both human outputs and simulation outputs.

Table 6.3

Estimated Marginal Means

Dependent variable	Output	Mean	Std. error	95% Confidence interval	
				Lower Bound	**Upper Bound**
Anxiety	Human Output	0.322	0.033	0.255	0.388
	Simulation Output	0.277	0.033	0.211	0.343
Self-efficacy	Human Output	0.366	0.021	0.324	0.408
	Simulation Output	0.346	0.021	0.304	0.388
Motivation	Human Output	0.566	0.033	0.500	0.632
	Simulation Output	0.547	0.033	0.481	0.614

Table 6.3 displays the model-estimated marginal means and standard errors of both human and simulation outputs on the three constructs of anxiety, self-efficacy and motivation. This table is particularly useful for exploring the differences between the levels of human and simulation outputs. While differences in means are observed, standard errors appear equal to the constructs. These results can be further represented in Figures 6.5.

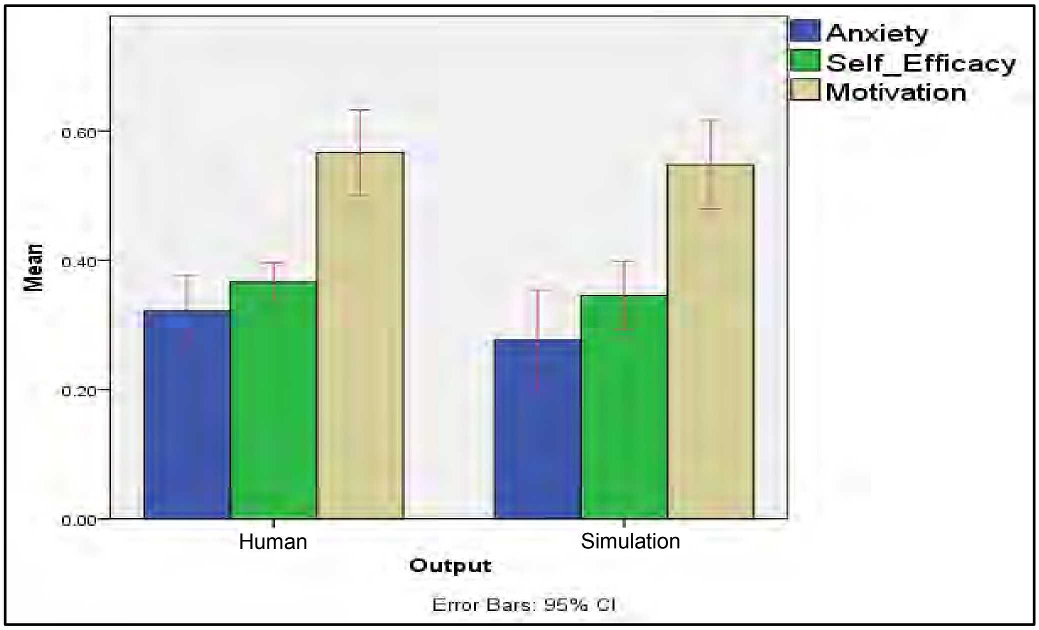

Figure 6.5. Clustered means and error bar

The chart presented in Figure 6.5 shows the clustered mean of the two entities (human and simulation) under comparison. Means of the three constructs with their error margin are shown. The bars for each of the constructs are similar in both human and simulation which is a strong indicator for the acceptability of the null hypothesis.

Table 6.4

Descriptive Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Output	Pillai's Trace	0.106	2.680[b]	3.000	68.000	0.054
	Wilks' Lambda	0.894	2.680[b]	3.000	68.000	0.054
	Hotelling's Trace	0.118	2.680[b]	3.000	68.000	0.054
	Roy's Largest Root	0.118	2.680[b]	3.000	68.000	0.054

a. Design: Intercept + Output

b. Exact statistic

Table 6.5

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Output	Motivation	0.006	1	0.006	0.157	0.693
	Self-Efficacy	0.008	1	0.008	0.489	0.487
	Anxiety	0.036	1	0.006	0.905	0.345
Error	Motivation	2.771	70	0.040		
	Self-Efficacy	1.118	70	0.016		
	Anxiety	2.785	70	0.040		
Total	Motivation	2.777	71			
	Self-Efficacy	1.126	71			
	Anxiety	2.821	71			

Table 6.4 displayed descriptive multivariate tests results of the two entities with three variables to compare. This is done by isolating the effect of one factor or variable from others that may distort conclusions (Price & Chamberlayne, 2008). The test of between-subjects effect shown in Table 6.5 presents the dependent variables (motivation, self-efficacy, and anxiety) in relation to their square mean, variance and level of significance. The significance of >0.05 in each case allude to our null hypothesis that the results from the two comparing entities (human and simulation outputs) are not significantly different.

The discrepancies of the competing entities in terms of dispersion are depicted in the line chart in Figure 6.7 below.

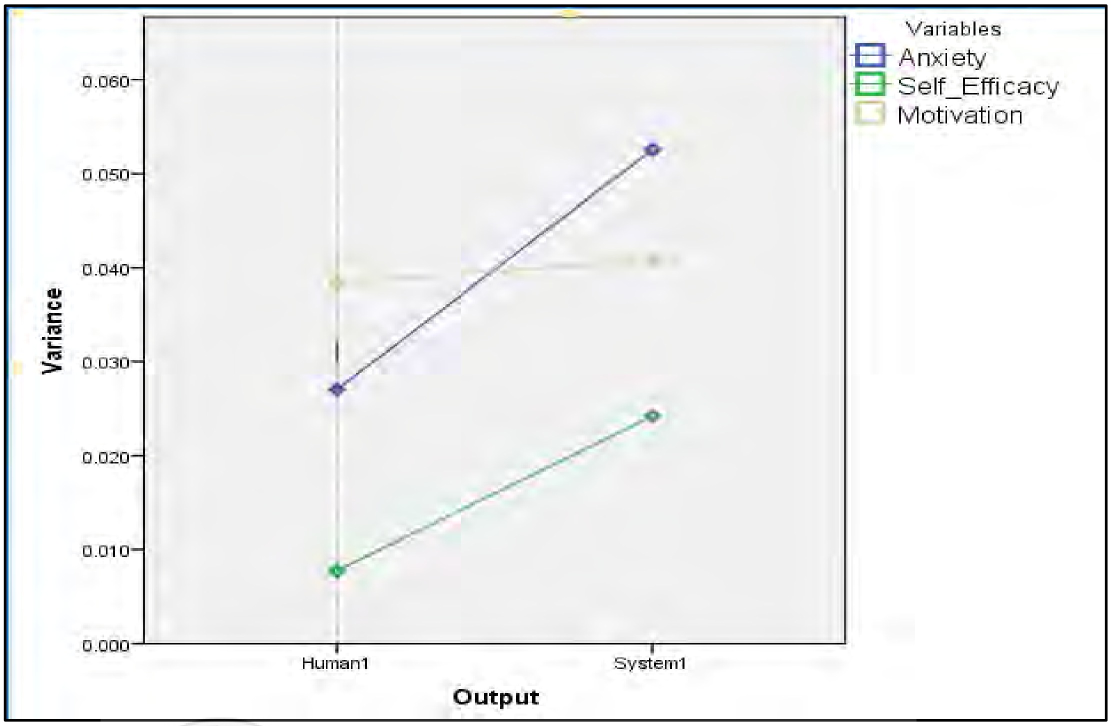

Figure 6.6. Line chart of variance

Variances of each of the constructs in the two comparing entities are displayed in Figure 6.6. Tables 6.2 and 6.3 represented in Figure 6.5, shows that the mean anxiety, self-efficacy and motivation appearing in the human system and the simulation results are not significantly different. However, mean values alone do not give the entire explanation about the system. It is also pertinent to show variability to get a complete picture about differences between the results. Measuring the dispersion (that is, variability) of the model output is used to validate the efficacy of the model under review (Majid et al., 2009). The variance as depicted in the graph shows how close the human outputs and simulation results are to the middle point of the distribution. It can be seen that motivation has very close variance range between human and simulation outputs hence proving the performance of the simulation in terms of motivation. Self-efficacy also has close range but there is a noticeable difference in anxiety variance between the two systems. Also, the high level of dispersion in simulation compared to human may be a result of parameter changes or stability related cases during different runs of the simulation.

6.6.3 Implication of Validation Experiment

From Table 6.4, since the p=0.054>0.05 for all the tests Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root, there is no basis to reject the null hypothesis. Hence it can be concluded that the human and simulated model produce results of anxiety, self-efficacy and motivation that are not significantly different. Moreover, Table 6.5 showing $p=0.693>0.05$ for motivation, $p=0.487>0.05$ for self-efficacy and $p=0.345>0.05$ for Anxiety further confirmed the significance in individual test for each of the variables. This non-rejection of the null hypothesis is a proof of validation of the integrated cognitive agent model of interviewee mental state.

6.7 Summary of the Chapter

This chapter evaluates the effectiveness of the inner working of the model and its accuracy in tandem with the features of the domain. The three constituent models and the integrated model were verified using the techniques of stability analyses and temporal trace logic. Cases were acknowledged in the literature that were mathematically analysed in each of the models to identify points of equilibrium. Similar cases were used in temporal trace language in order to logically traceback.

The operational validity of the integrated model was done with a human experiment conducted with 36 undergraduate students in their final years. Standardized instruments were adapted to get data from respondents in two stages arranged for before and after a simulated interview situation. Data from the human input factors were used to simulate the model and the results obtained analysed with SPSS indicates that the integrated model performed to expectations.

CHAPTER SEVEN

CONCLUSION

7.1 Introduction

This chapter summarizes the entire study and discusses the results obtained in relation to the research questions and objectives. The thesis is organized into seven chapters. While the problem is formulated and objectives are specified in Chapter One, the remaining chapters describe the methodology, models, experiments and evaluation results. This chapter is organized as follows. First, Section 7.2 revisits the objectives of the study relate them with the achieved objectives based on related chapters or sections. Second, Section 7.3 discusses the implication to the findings from this study from the cognitive computing and intelligent system design perspectives. Third, the limitations of this study are highlighted in Section 7.4. Finally, Section 7.5 provides important insights for the future work of the study.

7.2 Revisiting the Study Objectives

Primarily, this study aims to provide a scientific solution on a fundamental problem to design a cognitive agent model of interviewee mental state. To achieve this, a number of objectives have been detailed up. These objectives are revisited in the following sections.

7.2.1 Research Objective #1

To analyse the inter-related factors from domain theories in self-efficacy, motivation, and anxiety during interview sessions.

This objective was achieved and explained in Chapter Four through the analysis of related internal and external factors for three fundamental constructs of self-efficacy, motivation and anxiety. First, within the *self-efficacy* construct, 24 factors have been chosen based on 1) Social Cognitive Theory, 2) Self-efficacy theory, 3) Goal Theory and 4) Schunk's Model as grounded theories. These factors were presented in Table 4.2. Secondly, the motivation construct has 24 factors (presented in Table 4.3). The underlying theories that define this construct are 1) Expectancy-value Theory, 2) Self-determination theory, 3) Social cognitive theory, 4) Goal theory, 5) Flow theory, and 6) Unified Theory of Task-specific Motivation. Finally, the anxiety construct has 16 factors as summarized in Table 4.3. Those factors were obtained from the underlying theories of; 1) Test-taking Anxiety, 2) Generalized Anxiety Disorder Theory, and 3) Social Cognitive theory.

7.2.2 Research Objective #2

To develop formal cognitive agent models from the interviewee mental state constructs of self-efficacy, motivation, and anxiety.

First, the conceptual models for each designed construct were formalized (as in Chapter Four). Later, those conceptual models were formulated into a set of formal representation using the First-Order Ordinary Differential Equation. As results, a number of simulation traces was generated and reported in in Chapter Five. The summary of those equations and simulation of the agent models is shown in Table 7.1.

Table 7.1

Summary of the Equations and Model Results

Cognitive Agent Model	Formalization (Equations)	Simulations Results (Figures)	Simulations Settings
Self-efficacy	1 -17	5.2, 5.3, 5.4, 5.5, 5.6	Appendix G
Motivation	18 - 34	5.7, 5.8, 5.9, 5.10, 5.11	Appendix I
Anxiety	35 - 43	5.12, 5.13, 5.13, 5.14(a), 5.14(b)	Appendix K

Table 7.1 summarizes important information about the outcomes to support Objective # 2. Simulations figures represent the simulation results for defined scenarios of each model.

7.2.3 Research Objective #3

To integrate the formal cognitive agent models into a unified cognitive agent model that represents an interviewee mental state.

This objective is presented in both Chapter Four and Five. The conceptualization of an integrated model is presented in Figure 4.15 and formalized in Chapter Four (Equations 4.48 to 4.55). Scenarios were deduced from literature to simulate the integrated model in Chapter Five. The results of the simulation were presented in Figures 5.15 to 5.18.

7.2.4 Research Objective #4

To evaluate the designed cognitive agent model within simulated job interview domain.

In this thesis, Chapter Six presents the results from the evaluation processes. Related cases were selected from the literature for stability analysis and automated logical verification for each respective models to prove the correctness of the models. In addition, the integrated model was validated through human experiments. Results from 36 respondents were compared against generated simulation results from the integrated model. The Hotelling's T^2 statistical instrument has been used and the results have confirmed that outputs from the computational model are significantly similar to that of the human experiment. The detailed results can be found in Table 6.4. Table 7.2 summarizes the findings pertinent to the objectives and methods.

Table 7.2

Summary of the Study Findings

Objective	**Methods / Techniques**	**Outcomes**	**Chapter**
To analyse the inter-related factors from domain theories in motivation, anxiety and self-efficacy during interview sessions.	A critical literature review of theories, models and concepts in cognitive and psychology related to the constructs of self-efficacy, motivation and anxiety in interview domain.	Twenty-one factors were identified each for self-efficacy and motivation while fifteen identified for anxiety	Two and Four
To develop formal cognitive agent models from the interview mental state constructs (self-efficacy, motivation, and anxiety).	Agent-based modelling methodology and ordinary differential equation technique.	Conceptual models, formal models and simulation results	Four and Five
To integrate the formal cognitive agent models into a unified cognitive agent model that represents an interviewee mental state.	Agent-based modelling (Factors association)	Formalized Integrated agent model	Four and Five
To evaluate the designed cognitive agent model within simulated job interview domain.	Stability analysis, automatic verification (TTL) and human experiment validation	Verified and validated models	Six

7.3 Implication of Study

7.3.1 Theoretical Implication

The theoretical implication provides an important achievement of this study as it directly contributed towards the body of computer science. As the interplay between computer sciences, artificial intelligence, and cognitive sciences have becoming a monolithic body, thus the proposed models provide a building block for reasoning mechanisms. For example, the developed formal models help to better understand and explain in a logical manner of the underlying theories (Bartocci & Lió, 2016; Boden, 2008; Friedman et al., 2018; Keller, 2015). In addition, the simulated results provide possible insights both in computer science and cognitive psychology to explore more possibilities to understand and build intelligent systems within interview domains. .

7.3.2 Practical Implication

The main practical implication of this study could be viewed as integration into the human environment through devices that monitor the physical and mental state of the human. In this case, such integration would enhance the performance of the devices on an in-depth analysis of the human's functioning. This gives rise to an environment that effectively influences humans to undertake in knowledgeable manner actions that improve their well-being and performance (Treur, 2016b). Thus, the formalized cognitive model in its algorithmic form serves as the basis for building the intelligent artefact in the interview coaching domain. Therefore, such system would not just evaluate users based on physical actions but their behavioural tendencies could be decoded to serve as a basis for scientific analysis of actions.

7.4 Limitation of Study

The cognitive model in its current state has no adaptive learning mechanism hence its reasoning capacity can only be based on internal logic of the constituent models. In addition, the number of respondents can be added to have a better effect for a reliable data to qualify the behaviour and parameter tuning of the model. Furthermore, this study does not provide implementation frameworks to integrate the proposed models into a working prototype or system.

7.5 Future Work

The long-term goal of this research is to achieve an intelligent artefact integrated with interviewee behavioural tendencies in smart feedbacks during interview coaching. Thus, the future work of this study can be extended within these contexts;

7.5.1 Model Extension

The conceptual model of this study could be extended to robustly accommodate more of the array of constructs identified in the interviewee behavioural model. Despite the centrality of this study around the interviewee states influence, other constructs in interview design such as social stereotyping, cultural and religious belief systems could be included. Through these extensions, there is a sufficient granularity construct to answer more fundamental issues in interviewing behaviours and its dynamics, such as societal influences or life experiences.

7.5.2 Intelligent Support and Adaptation Model

In this study, the developed models are capable to analyse human behaviour based on environmental and social factors. However, in order to generate support for the human by (what-if) simulation (of the human environment interaction) and reasoning based on the domain model, a support model is required. Therefore, future work of this study can be viewed to add a support and adaptation module for required support based on the decision generated by a cognitive agent model. In addition, the adaptation model would enable an intelligent system reasoning process that is based on the cognitive agent model. This is can be achieved through the provision of automatic tuning of the parameters in the domain model to the specific characteristics of the human. In addition, the designed model armed with the support and adaption models can be an interesting area in algorithm design.

7.5.3 Integration with Social Agent/Robotic Platforms

Research in Embodied Conversation Agents (ECAs) with advanced anthropomorphic representation and sociable assistive robotics enables diverse applications in social interactive environment. Integration of the final cognitive agent model and its associated support and adaption models into such social assistive agent will be a novel approach in the interview coaching.

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APPENDICES

Appendix A

Experiment Participants' Consent Form

Participant Consent Form

My name is **Ajoge Naseer Sanni** and I am a PhD student at Universiti Utara Malaysia (UUM). My research interest is modeling the human mental state in the interview domain for the purpose of injecting digital interview coaching systems with relevant intelligence to understanding the dynamically changing interviewee behaviours.

Please read this consent document carefully before you decide to participate in this study experiment.

Purpose of the research study experiment: The purpose of this experiment is to validate the proposed Integrated Cognitive Agent Model for Interviewees' States Influence. This is to be achieved by measuring some factors which would be used as inputs to the model simulation environment and the output of the simulation would be compared with that of the experiment.

What you will be asked to do in the study experiment: A training session for the experiment would be given. There would be a pre-interview session where participants are administered with self-evaluating questionnaires on input factors. Subsequently, they would be invited to seat for a live interview. Post-interview questionnaires for output factors would then be administered for participants to complete.

Required duration for the interview: 15 minutes.

Date & Time for the experiment: ____

Venue: Hamman Tukur Computer Centre, Computer Science Department, Kaduna Polytechnic, Kaduna – Nigeria.

Risks: No risk is associated with this experiment.

Benefits / Compensation: There is a monetary compensation of N3000 ($10) for those who completes the experiment process.

Confidentiality: Your identity will be kept confidential to the extent provided by law. The participants' Id is only needed for data coding. When the study is completed and the data have been analysed, the profile lists of the participants will be destroyed. Your profile will not be used in any report.

Voluntary participation: Your participation in this study is voluntary. There is no penalty for not participating.

Right to withdraw from the study: You have the right to withdraw from the study at any time without consequence.

Permission to use your Photos and Videos: The researcher will take photos of the participants and record videos during the experiment. Do you permit the researcher to put your photo in his thesis?

Yes ☐ No ☐

Whom to contact if you have questions about the study experiment: Ajoge Naseer Sanni (School of Computing, Universiti Utara Malaysia) telephone (+60 11-3665 4261 or +234-803-642-4139), and email (ajogenass@yahoo.com); **Supervisors:** Dr. Azizi Ab Aziz, phone (+60 12-403 3654), email (aziziazi@uum.edu.my) and Dr. Shahrul Azmi Bin Mohd. Yusof, phone (+60 13-480 8554), email (shahrulazmi@uum.edu.my)

____

Participant **Signature** **Date**

I have read the procedure described above.
I voluntarily agree to participate in the experiment.

Appendix B

Pre-Interview Measuring Instruments

BACKGROUND INFORMATION

i. Id: ____

ii. Program of study ____

iii. Age__________________

iv. Please indicate your gender by marking in the appropriate space

Female ☐ Male ☐

v. Estimate your level of experience in respect to any form of selection interview.

- ☐ *Extensive experience*
- ☐ *Substantial experience*
- ☐ *Moderate experience*
- ☐ *Limited experience*
- ☐ *No experience*

Estimate the number of times you have taken selection interview task:

- ☐ *4 and above times*
- ☐ *3 times*
- ☐ *2 times*
- ☐ *1 times*
- ☐ *Never*

vi. How many times have you witnessed someone related to you (academic discipline, friend, family) performed successfully in an interview?

- ☐ *Never*
- ☐ *1 time*
- ☐ *2 times*
- ☐ *3 times*
- ☐ *4 and above*

Tool 1: **Index of Autonomous Functioning (IAF) scale**

Instructions: Below is a collection of statements about your general experiences. Please indicate how true each statement is of your experiences on the whole. Remember that there are no right or wrong answers. Please answer according to what really reflects your experience rather than what you think your experience should be.

not at all true	a bit true	somewhat true	mostly true	completely true
1	2	3	4	5

Indicate to which extend the following statement about you is true	**1**	**2**	**3**	**4**	**5**
Authorship/self-congruence					
1. My decisions represent my most important values and feelings					
2. I strongly identify with the things that I do					
3. My actions are congruent with who I really am					
4. My whole self stands behind the important decisions I make					
5. My decisions are steadily informed by things I want or care about					
Susceptibility to control					
6. I do things in order to avoid feeling badly about myself					
7. I do a lot of things to avoid feeling ashamed					
8. I try to manipulate myself into doing certain things					
9. I believe certain things so that others will like me					
10.I often pressure myself					
Interest-taking					
11. I often reflect on why I react the way I do.					
12. I am deeply curious when I react with fear or anxiety to events in my life.					
13. I am interested in understanding the reasons for my actions.					
14. I am interested in why I act the way I do.					
15. I like to investigate my feelings					

***Tool 2*: Short Form of Simple Rathus Assertiveness Scale SRAS-SF**

Instruction: One way to gain insight into how assertive you are is to take the following self-report test of assertive behaviour. Read each sentence carefully. Tick on each line whatever number is correct for you.

6 - very much like me
5 - rather like me
4 - somewhat like me
3 - somewhat unlike me
2 - rather unlike me
1 - very unlike me

Tick on each line whatever number is correct for you.	6	5	4	3	2	1
1. Most people stand up for themselves more than I do *						
2. At times I have not made or gone on dates because of my shyness *						
3. When I am eating out and the food I am served is not cooked the way I like it, I complain to the person serving it						
4. If a person serving in a store has gone to a lot of trouble to show me something which I do not really like, I have a hard time saying ―No" *						
5. There are times when I look for a good strong argument						
6. I try as hard to get ahead in life as most people like me do						
7. To be honest, people often get the better of me. *						
8. I do not like making phone calls to businesses or companies. *						
9. I feel silly if I return things I don't like to the store that I bought them from. *						
10. If a close relative that I like was upsetting me, I would hide my feelings rather than say that I was upset. *						
11. I have sometimes not asked questions for fear of sounding stupid. *						
12. During an argument I am sometimes afraid that I will get so upset that I will shake all over. *						
13. If a famous person were talking in a crowd and I thought he or she was wrong, I would get up and say what I thought						
14. If someone has been telling false and bad stories about me, I see him/her as soon as possible to ―have a talk" about it.						
15. I often have a hard time saying ―Noö *						
16. I complain about poor service when I am eating out or in other places						
17. When someone says I have done very well, I sometimes just don't know what to say. *						
18. If a couple near me in the theatre were talking rather loudly, I would ask them to be quiet or to go somewhere else and talk.						
19. I am quick to say what I think.						

Items with asterisk (*) are to be reverse scored.

Tool 3: **Multidimensional Scale of Perceived Social Support**

Instruction: We are interested in how you feel about the following statements regarding the supports you get from family, friends or others. Read each statement carefully and tick appropriate column per question.

1	2	3	4	5	6	7
Very Strongly disagree	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Very Strongly agree

Indicate how you feel about each statement using the following scale:	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. There is a special person who is around when I am in need.							
2. There is a special person with whom I can share my joys and sorrows.							
3. My family really tries to help me.							
4. I get the emotional help and support I need from my family.							
5. I have a special person who is a real source of comfort to me.							
6. My friends really try to help me.							
7. I can count on my friends when things go wrong.							
8. I can talk about my problems with my family.							
9. I have friends with whom I can share my joys and sorrows.							
10. There is a special person in my life who cares about my feelings.							
11. My family is willing to help me make decisions.							
12. I can talk about my problems with my friends.							

Tool 4: **Trait Anxiety Scale**

Instructions: A number of statements which people have used to describe themselves are given below. Read each statement and then **tick the appropriate cell of the number to the right of the statement to indicate how you generally feel**. There are no right or wrong answers. Do not spend much time on any one statement but give the answer which seems to describe how you generally feel.

Indicate how you generally feel	Almost Never	Sometimes	Often	Almost Always
	1	2	3	4
1. I feel pleasant				
2. I feel nervous and restless				
3. I am satisfied with myself				
4. I wish I could be as happy as others seems to be				
5. I feel like a failure				
6. I feel rested				
7. I am calm, cool and collected				
8. I feel that difficulties are piling up so that I cannot overcome them				
9. I worry too much over something that doesn't really matter				
10. I am happy				
11. I have disturbing thoughts				
12. I lack self-confidence				
13. I feel secured				
14. I make decision easily				
15. I feel inadequate				
16. I am content				
17. Some unimportant thought rune through my mind and bothers me				
18. I take disappointments so keenly that I can't put them out of my mind				
19. I am a steady person				
20. I get in a state of tension or turmoil as I think my recent concerns and interests.				

Appendix C

Post-Interview Measuring Instruments

Id: ________________

i. Rate the level of demand posed to you by this interview in terms of expected task difficulty, work and time involvement.

- ☐ *Extensively demanding*
- ☐ *Substantial demanding*
- ☐ *Moderate demanding*
- ☐ *Limited demands*
- ☐ *Not demanding*

ii. During the interview, rate the interviewer in terms of persuasion or expression of encouragement to you either before or during the session.

- ☐ *Not at all*
- ☐ *Somewhat*
- ☐ *Moderately*
- ☐ *Very much*

Tool 5: **Perceived Relatedness**

Instruction: Here is a list of statements about what you may feel towards the interviewer or the panel during the interview. Please indicate to what extent you agree with each of the following items.

Do not agree at all	Very Slightly agree	Slightly agree	Moderately agree	Agree	Strongly agree	Very Strongly agree
1	2	3	4	5	6	7

In my relationship with the interviewer during the interview process, I feel ...	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1) ……… supported							
2) ……… close to him/her							
3) ……… understood							
4) ……… attached to him/her.							
5) ……… listened to							
6) ……… bonded to him/her.							
7) ……… valued.							
8) ……… close-knit							
9) ………. safe.							
10)……… as a friend.							

Tool 6: **State Anxiety Sub-scale**

Instruction: A number of statements which people have used to describe themselves are given below. Read each statement and then mark the appropriate number to the right of the statement **to indicate how you feel right during the interview.** There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your feelings best at that moment.

Indicate how you feel right during the interview.	Not at all	Some what	Moderately so	Very much so
	1	2	3	4
1. I feel calm				
2. I feel secure				
3. I am tense				
4. I feel strained				
5. I feel at ease				
6. I feel upset				
7. I am presently worrying over possible misfortune				
8. I feel satisfied				
9. I feel frightened				
10. I feel comfortable				
11. I feel self-confident				
12. I feel nervous				
13. I am jittery				
14. I feel indecisive				
15. I am relaxed				
16. I feel content				
17. I am worried				
18. I am confused				
19. I am steady				
20. I feel pleasant				

Tool 7: **Generalized Self-efficacy scale (GSE)**

Instruction: This scale is a self-report measure of self-efficacy. Indicate how you feel from the items in the table below during the interview. Relate each statement to the interview task.

Items	Not at all true	Hardly true	Moderately true	Exactly true
	1	**2**	**3**	**4**
1. I can always manage to solve difficult problems if I try hard enough				
2. Even when I am opposed during the interview, I can find the means and ways to get my response out. *				
3. It is easy for me to stick to my aims and accomplish my goals.				
4. I am confident that I could deal efficiently with unexpected events.				
5. Thanks to my resourcefulness, I know how to handle all the interview situations. *				
6. I can answer all questions if I invest the necessary effort. *				
7. I can remain calm when facing difficulties because I can rely on my coping abilities.				
8. When I am confronted with difficult questions in the interview, I can usually find several solutions.*				
9. If I am in trouble, I can usually think of a solution				
10. I can usually handle whatever comes my way.				

Tool 7: **Short Form of Questionnaire on Current Motivation**

Instruction: Read each sentence carefully. Tick the appropriate number according to your level of agreement with the senesce. Relate each statement to your thought before or during the last interview and indicate your level of agreement.

1	2	3	4	5	6	7
Very Strongly disagree	Strongly disagree	Mildly disagree	Neutral	Mildly agree	Strongly agree	Very Strongly agree

Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. I think I am up to the difficulty of this interview task							
2. I probably managed to do the interview **							
3. I feel under pressure to do the interview well*							
4. After having understood the instruction, the task seems to be very interesting to me *							
5. I am eager to see how I will perform in the interview *							
6. I am afraid I have made a fool out of myself *							
7. I really tried as hard as I could on the task *							
8. For tasks like this I do not need a reward, they are lots of fun anyhow							
9. It would be embarrassing to fail the interview *							
10. I think everyone could do well on the interview *							
11. If I do well on this task, I would be proud of myself *							
12. I would like to take the interview again even for leisure *							

Appendix D

Coded Data from Instruments

SN	ID	SEX	Experience	Experience	vicarious Exp	Autonomy	Assertiveness	social sup	Trait	Task Demand	Persuassion	relatedness	Anxiety	Self-efficacy	Motivation
			Raw Data												
Total score obtainable			5	4	5	75	114	84	80	5	4	70	80	40	84
1	16/14545	F	2	2	2	46	50	78	39	2	3	40	27	37	68
2	01/14426	M	3	4	3	52	54	57	47	4	3	42	41	32	69
3	16/15010	F	2	3	4	60	63	65	53	2	4	52	42	36	67
4	16/14543	F	1	1	1	57	61	66	32	3	4	47	43	36	60
5	16/14420	M	4	3	3	49	64	66	46	4	3	51	41	32	54
6	16/14343	M	3	3	5	50	49	73	43	3	3	43	44	35	65
7	16/14484	M	2	2	1	54	55	67	46	1	3	48	37	27	61
8	16/14476	F	1	1	2	52	59	61	48	3	4	49	41	35	57
9	16/11287	F	3	4	5	69	69	71	45	3	3	44	27	31	62
10	16/15001	M	2	2	2	27	46	66	46	1	3	55	36	34	54
11	16/14949	M	3	4	5	55	54	68	35	3	4	49	27	31	64
12	16/14441	F	4	4	5	55	50	70	48	2	4	61	36	35	69
13	16/14474	F	3	3	4	72	45	57	41	3	4	54	37	35	54
14	16/14939	F	3	4	3	55	44	57	47	3	2	47	46	29	57
15	16/14550	M	2	1	5	48	55	70	43	3	3	10	27	38	66
16	16/14527	F	1	2	5	54	64	71	50	3	1	46	39	32	46
17	16/14504	M	2	1	1	44	53	65	50	3	4	47	34	34	41
18	16/14352	M	3	3	4	51	52	75	43	3	4	50	33	37	65
19	16/14429	F	4	3	3	53	43	53	49	3	4	59	49	29	65
20	16/14533	F	1	1	2	58	73	70	41	3	3	54	35	32	76
21	16/14940	M	3	3	4	58	41	71	37	4	1	54	32	37	51
22	16/14330	M	1	1	1	56	58	65	52	3	3	52	25	30	60
23	16/14485	M	1	1	2	39	58	51	47	4	4	43	41	32	55
24	16/14529	M	3	1	1	53	49	52	43	1	3	49	42	35	56
25	16/14418	M	3	3	4	55	61	71	44	4	4	54	32	31	51
26	16/14386	M	4	4	3	57	55	66	44	4	3	39	23	24	41
27	16/14397	F	4	4	5	50	52	80	42	4	4	63	34	38	57
28	16/14443	M	3	4	5	47	83	69	44	3	3	54	34	35	49
29	16/14407	M	2	2	1	48	62	54	48	3	3	65	49	32	16
30	16/14998	M	2	3	2	54	72	75	48	3	1	22	36	40	66
31	16/14442	M	3	4	3	50	70	55	43	3	3	33	35	33	53
32	16/14391	M	2	3	3	54	72	70	37	1	1	57	31	29	44
33	16/14399	F	1	1	5	49	62	70	41	3	2	49	25	28	65
34	16/14390	M	5	4	3	66	77	81	43	3	1	31	26	36	69
35	16/14388	M	4	4	4	56	61	54	35	5	1	50	33	32	55
36	16/14999	F	1	1	1	49	47	62	44	4	3	53	64	17	24

SN	PE	VX	PA	PN	SS	TR	TD	VP	RD	Lw	Lf	Lm
	Converted Data											
Total score obtainable												
1	0.4	0.4	0.6	0.4	0.9	0.5	0.4	0.8	0.6	0.3	0.9	0.8
2	0.8	0.6	0.7	0.5	0.7	0.6	0.8	0.8	0.6	0.5	0.8	0.8
3	0.6	0.8	0.8	0.6	0.8	0.7	0.4	1.0	0.7	0.5	0.9	0.8
4	0.2	0.2	0.8	0.5	0.8	0.4	0.6	1.0	0.7	0.5	0.9	0.7
5	0.8	0.6	0.7	0.6	0.8	0.6	0.8	0.8	0.7	0.5	0.8	0.6
6	0.7	1.0	0.7	0.4	0.9	0.5	0.6	0.8	0.6	0.6	0.9	0.8
7	0.4	0.2	0.7	0.5	0.8	0.6	0.2	0.8	0.7	0.5	0.7	0.7
8	0.2	0.4	0.7	0.5	0.7	0.6	0.6	1.0	0.7	0.5	0.9	0.7
9	0.8	1.0	0.9	0.6	0.8	0.6	0.6	0.8	0.6	0.3	0.8	0.7
10	0.4	0.4	0.4	0.4	0.8	0.6	0.2	0.8	0.8	0.5	0.9	0.6
11	0.8	1.0	0.7	0.5	0.8	0.4	0.6	1.0	0.7	0.3	0.8	0.8
12	0.9	1.0	0.7	0.4	0.8	0.6	0.4	1.0	0.9	0.5	0.9	0.8
13	0.7	0.8	1.0	0.4	0.7	0.5	0.6	1.0	0.8	0.5	0.9	0.6
14	0.8	0.6	0.7	0.4	0.7	0.6	0.6	0.5	0.7	0.6	0.7	0.7
15	0.3	1.0	0.6	0.5	0.8	0.5	0.6	0.8	0.1	0.3	1.0	0.8
16	0.3	1.0	0.7	0.6	0.8	0.6	0.6	0.3	0.7	0.5	0.8	0.5
17	0.3	0.2	0.6	0.5	0.8	0.6	0.6	1.0	0.7	0.4	0.9	0.5
18	0.7	0.8	0.7	0.5	0.9	0.5	0.6	1.0	0.7	0.4	0.9	0.8
19	0.8	0.6	0.7	0.4	0.6	0.6	0.6	1.0	0.8	0.6	0.7	0.8
20	0.2	0.4	0.8	0.6	0.8	0.5	0.6	0.8	0.8	0.4	0.8	0.9
21	0.7	0.8	0.8	0.4	0.8	0.5	0.8	0.3	0.8	0.4	0.9	0.6
22	0.2	0.2	0.7	0.5	0.8	0.7	0.6	0.8	0.7	0.3	0.8	0.7
23	0.2	0.4	0.5	0.5	0.6	0.6	0.8	1.0	0.6	0.5	0.8	0.7
24	0.4	0.2	0.7	0.4	0.6	0.5	0.2	0.8	0.7	0.5	0.9	0.7
25	0.7	0.8	0.7	0.5	0.8	0.6	0.8	1.0	0.8	0.4	0.8	0.6
26	0.9	0.6	0.8	0.5	0.8	0.6	0.8	0.8	0.6	0.3	0.6	0.5
27	0.9	1.0	0.7	0.5	1.0	0.5	0.8	1.0	0.9	0.4	1.0	0.7
28	0.8	1.0	0.6	0.7	0.8	0.6	0.6	0.8	0.8	0.4	0.9	0.6
29	0.4	0.2	0.6	0.5	0.6	0.6	0.6	0.8	0.9	0.6	0.8	0.2
30	0.6	0.4	0.7	0.6	0.9	0.6	0.6	0.3	0.3	0.5	1.0	0.8
31	0.8	0.6	0.7	0.6	0.7	0.5	0.6	0.8	0.5	0.4	0.8	0.6
32	0.6	0.6	0.7	0.6	0.8	0.5	0.2	0.3	0.8	0.4	0.7	0.5
33	0.2	1.0	0.7	0.5	0.8	0.5	0.6	0.5	0.7	0.3	0.7	0.8
34	1.0	0.6	0.9	0.7	1.0	0.5	0.6	0.3	0.4	0.3	0.9	0.8
35	0.9	0.8	0.7	0.5	0.6	0.4	1	0.3	0.7	0.4	0.8	0.7
36	0.2	0.2	0.7	0.4	0.7	0.6	0.8	0.8	0.8	0.8	0.4	0.3

Appendix E

Generated Data from Human Experiment and Simulation

	INPUTS									Human Output			Simulation Output		
sn	PE	VX	PA	PN	SS	TR	TD	VP	RD	Lw	Lf	Lm	Lw	Lf	Lm
1	0.4	0.4	0.6	0.4	0.9	0.5	0.4	0.8	0.6	0.3	0.9	0.8	0.4	0.6	0.8
2	0.8	0.6	0.7	0.5	0.7	0.6	0.8	0.8	0.6	0.5	0.8	0.8	0.5	0.7	0.8
3	0.6	0.8	0.8	0.6	0.8	0.7	0.4	1.0	0.7	0.5	0.9	0.8	0.4	0.6	0.6
4	0.2	0.2	0.8	0.5	0.8	0.4	0.6	1.0	0.7	0.5	0.9	0.7	0.8	0.6	0.5
5	0.8	0.6	0.7	0.6	0.8	0.6	0.8	0.8	0.7	0.5	0.8	0.6	0.4	0.7	0.7
6	0.7	1.0	0.7	0.4	0.9	0.5	0.6	0.8	0.6	0.6	0.9	0.8	0.5	0.8	0.9
7	0.4	0.2	0.7	0.5	0.8	0.6	0.2	0.8	0.7	0.5	0.7	0.7	0.4	0.7	0.8
8	0.2	0.4	0.7	0.5	0.7	0.6	0.6	1.0	0.7	0.5	0.9	0.7	0.3	0.8	0.9
9	0.8	1.0	0.9	0.6	0.8	0.6	0.6	0.8	0.6	0.3	0.8	0.7	0.3	0.7	0.8
10	0.4	0.4	0.4	0.4	0.8	0.6	0.2	0.8	0.8	0.5	0.9	0.6	0.5	0.9	0.7
11	0.8	1.0	0.7	0.5	0.8	0.4	0.6	1.0	0.7	0.3	0.8	0.8	0.4	0.7	0.8
12	0.9	1.0	0.7	0.4	0.8	0.6	0.4	1.0	0.9	0.5	0.9	0.8	0.4	0.8	0.9
13	0.7	0.8	1.0	0.4	0.7	0.5	0.6	1.0	0.8	0.5	0.9	0.6	0.4	0.8	0.7
14	0.8	0.6	0.7	0.4	0.7	0.6	0.6	0.5	0.7	0.6	0.7	0.7	0.5	0.8	0.7
15	0.3	1.0	0.6	0.5	0.8	0.5	0.6	0.8	0.1	0.3	1.0	0.8	0.2	0.8	0.9
16	0.3	1.0	0.7	0.6	0.8	0.6	0.6	0.3	0.7	0.5	0.8	0.5	0.4	0.7	0.8
17	0.3	0.2	0.6	0.5	0.8	0.6	0.6	1.0	0.7	0.4	0.9	0.5	0.4	0.8	0.8
18	0.7	0.8	0.7	0.5	0.9	0.5	0.6	1.0	0.7	0.4	0.9	0.8	0.4	0.8	0.8
19	0.8	0.6	0.7	0.4	0.6	0.6	0.6	1.0	0.8	0.6	0.7	0.8	0.6	0.6	0.5
20	0.2	0.4	0.8	0.6	0.8	0.5	0.6	0.8	0.8	0.4	0.8	0.9	0.5	0.8	0.8
21	0.7	0.8	0.8	0.4	0.8	0.5	0.8	0.3	0.8	0.4	0.9	0.6	0.4	0.8	0.8
22	0.2	0.2	0.7	0.5	0.8	0.7	0.6	0.8	0.7	0.3	0.8	0.7	0.2	0.7	0.7
23	0.2	0.4	0.5	0.5	0.6	0.6	0.8	1.0	0.6	0.5	0.8	0.7	0.5	0.7	0.8
24	0.4	0.2	0.7	0.4	0.6	0.5	0.2	0.8	0.7	0.5	0.9	0.7	0.6	0.5	0.4
25	0.7	0.8	0.7	0.5	0.8	0.6	0.8	1.0	0.8	0.4	0.8	0.6	0.4	0.7	0.7
26	0.9	0.6	0.8	0.5	0.8	0.6	0.8	0.8	0.6	0.3	0.6	0.5	0.3	0.8	0.9
27	0.9	1.0	0.7	0.5	1.0	0.5	0.8	1.0	0.9	0.4	1.0	0.7	0.3	0.8	0.8
28	0.8	1.0	0.6	0.7	0.8	0.6	0.6	0.8	0.8	0.4	0.9	0.6	0.4	0.7	0.7
29	0.4	0.2	0.6	0.5	0.6	0.6	0.6	0.8	0.9	0.6	0.8	0.2	0.7	0.4	0.2
30	0.6	0.4	0.7	0.6	0.9	0.6	0.6	0.3	0.3	0.5	1.0	0.8	0.4	0.8	0.8
31	0.8	0.6	0.7	0.6	0.7	0.5	0.6	0.8	0.5	0.4	0.8	0.6	0.4	0.7	0.8
32	0.6	0.6	0.7	0.6	0.8	0.5	0.2	0.3	0.8	0.4	0.7	0.5	0.4	0.6	0.6
33	0.2	1.0	0.7	0.5	0.8	0.5	0.6	0.5	0.7	0.3	0.7	0.8	0.4	0.7	0.7
34	1.0	0.6	0.9	0.7	1.0	0.5	0.6	0.3	0.4	0.3	0.9	0.8	0.3	0.8	0.8
35	0.9	0.8	0.7	0.5	0.6	0.4	1.0	0.3	0.7	0.4	0.8	0.7	0.3	0.7	0.8
36	0.2	0.2	0.7	0.4	0.7	0.6	0.8	0.8	0.8	0.8	0.4	0.3	0.8	0.4	0.3

Appendix F

Samples Pictures During the Experiment

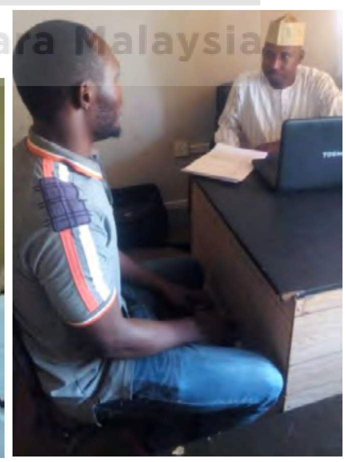
(I) Students during introduction of the experiment (Before Sample Selection)

(II) Pre-interview session

The picture above represents where the experimenter is introducing the instrument to the respondents explaining to them an item at a time while also clearing their doubts and questions.

(III) Group photograph with the respondents after the pre-interview self-assessment survey session

(IV) Interview sessions



(V) Photos with the Interviewers (Lecturers)

Appendix G

Simulation Code for Interviewee Self-Efficacy Agent

```
%clc
%Intializing all parameters to regulate the equations

    maxLimY = 1.2;
    minLimX = 0;
    numStep = 500; % 2 hours of interview (120 mins)

    % parameters of Instantanious factors
    Was = 0.5;     % Weight of Anxiety in Affective State. (1-Was) for Basic Efficacy
    Wep = 0.5;     % Weight of Mastery experience in Experience. (1-Wep) for Vicarious Experience
    alphaEi = 0.5; % For Experience in Efficacy information. (1-alphaEi) for Verbal persuation
    betaBe = 0.5;  % Social support in Basic Efficacy. (1-betaBe) for Mastery Experience
    gammaSk= 0.1;  % For skill. (1-gammaSk) for Long term persistence     CHANGED FROM 0.5

    phiGp = 0.8;   % inner factors for personal goal. (1-phiGp) for progress towards goal CHANGED FROM
0.5
    rhoGp = 0.5;   % Basic efficacy in Personal Goal. (1-rhoGp) for Mastery experience
    Wsp1 = 0.25;    % weight of Basic Efficacy in Short-Term Persistence.
    Wsp2 = 0.25;    % weight of short-term engagement in Short-Term Persistence.
    Wsp3 = 0.25;    % weight of goal in Short-Term Persistence.
    Wsp4 = 0.25;    % weight of long-term efficacy in Short-Term Persistence.
    betaSe = 0.5;  % Internal factors [Be, Sp]of Short-Term engagement. (1-betaSe) for external factors
[Pg,Gf].
    Wse1 = 0.5;    % Basic Efficacy in Short-Term Cognitive engagement. (1-Wse1) for short term
persistence
    Wse2 = 0.5;    % Progress towards goal in Short-Term Cognitive engagement. (1-Wse2) for Generated
effort
    alphaEa = 0.6; % Internal factors [Ei, Gp]of Efficacy appraisal. (1-alphaEa) for external factors [Le,Mf].
    Wea1 = 0.5;    % Efficacy information in Efficacy Appraisal. (1-Wea1) for personal goal
    Wea2 = 0.5;    % Long-term cognitive engagement in Efficacy Appraisal. (1-Wea2) for Mental effort
    gammaMf = 0.5; % External factors [Gp, Gf]of mental Effort. (1-gammaMf) for internal factor [Be].
    psiMf = 0.5;   % Personal goal in Mental Effort. (1-psiMf) for Generated effort.
    Wgf = 0.5;     % Mental effort in Generated effort. (1-Wgf) for short-term efficacy
    Wpg1 = 0.33;    % Short-term efficacy in Progress towards goal
    Wpg2 = 0.33;    % Long-term persistence in Progress towards goal
    Wpg3 = 0.33;    % Mental effort in Progress towards goal
    lamdaSf = 0.7; % Internal factors [Be, Ea, Lp]of Short-term Efficacy. (1-lamdaSf) for external factors
[Gp].
    Wsf1 = 0.33;    % Basic efficacy in short-term efficacy
    Wsf2 = 0.33;    % Efficacy appraisal in short-term efficacy
    Wsf3 = 0.33;    % Long term persistence in short-term efficacy
    Wlp = 0.5;     % sgot termpersistence in long term persistence. (1-wlp) for
    Delta_t = 0.2; % Change in time
    betaLe = 0.5;  % Accumulative Short term Cognitive Engagement
    alphaLp = 0.5; % Accumulative Short term Persistence
    gammaSf = 0.5; % Short term efficacy
    gammaLf = 0.5; % Accumulative Short term Self Efficacy
```

```
%DECLARE ALL VARIABLES AND SET initial VALUES TO EXTERNAL factors
   zz=zeros(4,500);
% External variables
    Ax=zeros(1,numStep); % Anxiety - Arousal interpretation
    Vp=zeros(1,numStep); % Verbal persuasion
    Ve=zeros(1,numStep); % Vicarious experience
    Me=zeros(1,numStep); % Mastery experience
    Ss=zeros(1,numStep); % Social support
    Ps=zeros(1,numStep); % Personality
    Td=zeros(1,numStep); % Task Demand

% Instantanious variables
    As=zeros(1,numStep); % Affective state
    Ep=zeros(1,numStep); % Experience
    Ei=zeros(1,numStep); % Efficacy Information
    Be=zeros(1,numStep); % Basic Efficacy
    Pd=zeros(1,numStep); % Percieved Task Difficulty
    Sk=zeros(1,numStep); % Skill
    Gp=zeros(1,numStep); % Personal Goal
    Sp=zeros(1,numStep); % Short-term persistence
    Se=zeros(1,numStep); % Short-term congitive engagement
    Ea=zeros(1,numStep); % Efficacy appraisal
    Mf=zeros(1,numStep); % Mental Effort
    Gf=zeros(1,numStep); % Generated Effort
    Pg=zeros(1,numStep); % Progress towards Goal

   % cSf=zeros(1,numStep); % combination function for short term efficacy
% Temporal variables
    Lp=zeros(1,numStep); % Long-term Persistence
    Le=zeros(1,numStep); % Long-term cognitive engagement
    Sf=zeros(1,numStep); % Short-term Self Efficacy
    Lf=zeros(1,numStep); % Long-term Self Efficacy

% Initializing temporal Factors

    Lp(1)=0.3;
    Le(1)=0.3;
    %Sf(1)=0.1;
    Lf(1)=0.1;

% initializing external factors
 % creating scenarios
 agent=4;
 flag = true;
while flag
 Scenario=agent;

   for t=1:numStep
      switch (Scenario)
    % A Good sitiation where a less anxious person, have supports (social,
    % vicarious, and verbal), with reasonable levely of positive mastery
```

```
    % experience with average interview difficulty and average skill.
      case(1)
       Ax(t)=0.2;
       Vp(t)=0.7;
       Ve(t)=0.7;
       Me(t)=1;
       Ss(t)=0.8;
       Ps(t)=0.7;
       Td(t)=0.5;
       SKnorm = 0.6;
    %  A completely bad case where an Anxious personality has low Mastery Experience, low social
support, low skill and difficult interview task

      case(2)
       Ax(t)=0.8;
       Vp(t)=0.1;
       Ve(t)=0.1;
       Me(t)=0.5;
       Ss(t)=0.8;
       Ps(t)=0.7;
       Td(t)=0.5;
       SKnorm = 0.6;

    %  Testing the effect of Mastery Experience. A low Mastery experience and low skill with other
favourable conditions produce a
    %  discouraging efficacy and long term cognitive engagement
     case(3)

      Ax(t)=0.2;
       Vp(t)=0.7;
       Ve(t)=0.7;
       Me(t)=0.5;
       Ss(t)=0.1;
       Ps(t)=0.1;
       Td(t)=0.5;
       SKnorm = 0.6;
    %  Testing the absence of Verbal persuation, Vicarious experience, and
    %  high Anxiety state but with high Mastery Experience on final efficacy.
      case(4)
       Ax(t)=0.8;
       Vp(t)=0.1;
       Ve(t)=0.1;
       Me(t)=0.1;
       Ss(t)=0.1;
       Ps(t)=0.1;
       Td(t)=0.5;
       SKnorm = 0.6;

      end

  end

% initialize Internal Factors at time, t=1
```

```
    Be(t) = (betaBe * Ss(t) + (1-betaBe)* Me(t)) * Ps(t);
    As(t) = Ax(t) * (1-Be(t));
    Ep(t) = Wep * Me(t) + (1-Wep)*Ve(t);
    Ei(t) = (alphaEi * Ep(t) + (1-alphaEi) * Vp(t)) * (1 - As(t));

    Sk(t)= gammaSk * SKnorm + (1 - gammaSk) * Lp(t);
    Pd(t)= Td(t) * (1-Sk(t));
    Gp(t)= phiGp * ((rhoGp*Be(t)+(1-rhoGp)*Me(t))*(1-Pd(t)))+(1-phiGp)* Pg(t);
    Sp(t) = Wsp1 * Be(t) + Wsp2*Se(t) + Wsp3*Gp(t) + Wsp4*Lf(t);
    Se(t) = betaSe * (Wse1*Be(t)+(1-Wse1) * Sk(t)) + (1-betaSe) * (Wse2*Pg(t) + (1-Wse2)*Gf(t));
    Ea(t) = alphaEa * (Wea1*Ei(t) + (1-Wea1)*Gp(t)) + (1-alphaEa) * (Wea2*Le(t) + (1-Wea2)*Mf(t));
    Gf(t) = Wgf * Mf(t) + (1-Wgf) * Sf(t);
    Mf(t) = gammaMf * (psiMf*Gp(t) + (1-psiMf)*Gf(t)) + (1-gammaMf)*Be(t);

    Pg(t) = Wpg1 * Sf(t) + Wpg2 * Lp(t) + Wpg3 * Mf(t);
    Sf(t) = lamdaSf * (Wsf1*Gp(t) + Wsf2*Ea(t) + Wsf3*Lp(t)) + (1-lamdaSf)*Be(t);
   % cSf(t) = lamdaSf * (Wsf1*Be(t) + Wsf2*Ea(t)) + (1-lamdaSf)*Gp(t);

    %%%% Re(t)= max((0.5* Ca(1)+0.5*Cp(1))-Me(1),0) ;
    %%%% Rm(1)= Pr(1) * ( 1 - ( GammaRm* Ae(1) + (1-GammaRm) * Cl(1) ));

% Run the Model at time, t=2
for t = 2:numStep

    % Instantaneous Factors
    % Basic Efficacy
    Be(t) = (betaBe * Ss(t) + (1-betaBe)* Me(t)) * Ps(t);
    % Affective state
    As(t) = Ax(t) * (1-Be(t));
    % Experiennce
    Ep(t) = Wep * Me(t) + (1-Wep)*Ve(t);
    % Efficacy information
    Ei(t) = (alphaEi * Ep(t) + (1-alphaEi) * Vp(t)) * (1 - As(t));

    % Skills
    Sk(t)= gammaSk * SKnorm + (1 - gammaSk) * Lp(t-1);
    % Percieved Task Difficulty
    Pd(t)= Td(t) * (1-Sk(t));
    % Personal Goal
    Gp(t)= phiGp * ((rhoGp*Be(t)+(1-rhoGp)*Me(t))*(1-Pd(t)))+(1-phiGp)* Pg(t);
    % Short-Term Persistence
    Sp(t) = Wsp1 * Be(t) + Wsp2*Se(t) + Wsp3*Gp(t) + Wsp4*Lf(t-1);
    % Short-Term Cognitive Engagement
    Se(t) = betaSe * (Wse1*Be(t)+(1-Wse1) * Sk(t)) + (1-betaSe) * (Wse2*Pg(t) + (1-Wse2)*Gf(t));
    % Efficacy Appraisal
    Ea(t) = alphaEa * (Wea1*Ei(t) + (1-Wea1)*Gp(t)) + (1-alphaEa) * (Wea2*Le(t-1) + (1-Wea2)*Mf(t));
     % Generated Effort
    Gf(t) = Wgf * Mf(t) + (1-Wgf) * Sf(t);
    % Mental Effort
    Mf(t) = gammaMf * (psiMf*Gp(t) + (1-psiMf)*Gf(t)) + (1-gammaMf)*Be(t);

    % Progress towards Goal
```

```
    Pg(t) = Wpg1 * Sf(t-1) + Wpg2 * Lp(t) + Wpg3 * Mf(t);
    % Short-Term Self Efficacy
    Sf(t) = lamdaSf * (Wsf1*Gp(t) + Wsf2*Ea(t) + Wsf3*Lp(t-1)) + (1-lamdaSf)*Be(t);

   %%cSf(t) = lamdaSf * (Wsf1*Be(t) + Wsf2*Ea(t)) + (1-lamdaSf)*Gp(t);
    %Temporal Factors

% %      x1(t)= - 1 * (Ml(t)-Me(t));
% %      x2(t)= 1 / ( 1+exp(x1(t)));


    % Accumulative Short-term cognitive engagement
    Le(t)= Le(t-1) + betaLe * (Se(t) - Le(t-1))* Le(t-1) * (1-Le(t-1))* Delta_t;

    % Accumulative Short-term Peristence
    Lp(t) = Lp(t-1) + alphaLp * (Sp(t) - Lp(t-1))* Lp(t-1) * (1-Lp(t-1)) * Delta_t;
    % short-term self efficacy
   % Sf(t)=Sf(t-1)+ gammaSf *(cSf(t) - Sf(t-1))*Sf(t-1)*(1-Sf(t-1))* Delta_t;
    % long term
    Lf(t) = Lf(t-1) + gammaLf * (Sf(t) - Lf(t-1)) * Lf(t-1) * (1-Lf(t-1)) * Delta_t;
    zz(agent,t)=Lf(t-1) + gammaLf * (Sf(t) - Lf(t-1)) * Lf(t-1) * (1-Lf(t-1)) * Delta_t;
end
   if agent == 4;
     flag=false;
   else
   agent=agent+1;
   end
end

% plotting graphs
%x = linspace (300,1,500);
%maxLimY = 1.2;
%     minLimX = 0;
%z=zeros(1,500);
%yy=zeros(2,500);
yy=[Lp;Le];

% z=Le(x);
mesh(zz(1:agent,1:500));
%mesh(yy(1:2,1:500));



%surf(zz(1:4,1:500));
% % hold on;
% % k=Lf(x);
% % mesh(x,y,k);
% % hold on;
% % p=Lp(x);
% % mesh(x,y,p);
% % hold on;
% % b=Be(x);
% % mesh(x,y,b);
```

```
% legend('LT engagement', 'LT Efficacy', 'LT Persistence')
%camlight, lighting phong;
%shading interp;
%t=1:numStep;

%y= plot(t, Be,'m--',t, Le,'m-.',t, Lp,'b--',t, Sf,'k-.',t, Lf,'r--');

 %xlabel('time steps');ylabel('levels');
 %xlim([0 numStep]);ylim([minLimX maxLimY]);
 %hold off;
 %legend(y,'Basic efficacy', 'Cognitive engagement', 'Persistence LT','ST Efficacy', 'LT efficacy');
% %*************************************************************************
% subplot(4,1,3);
% y = plot(t, Sa,'k-.',t, Rp,'r--',t, Ca,'b--');
% xlabel('time steps');ylabel('levels');
% xlim([0 numStep]);ylim([minLimX maxLimY]);
% hold off;
% legend(y,'sa', 'pe','ça');
%
% %*************************************************************************
% subplot(4,1,4);
% y = plot(t, Ae,'k-.',t, Ce,'b--',t,Gd,'r--');
% xlabel('time steps');ylabel('levels');
% xlim([0 numStep]);ylim([minLimX maxLimY]);
% hold off;
% legend(y,'Lc', 'Rd', 'Germane');
```

Appendix H

Simulation Code for Interviewee Motivation Agent

```
%Intializing all parameters to regulate the equations

    maxLimY = 1;
    minLimX = 0;
    numStep = 500; % 2 hours of interview (120 mins)

    % parameters of Instantanious factors
    Wpr = 0.5;     % Weight of interviewer disposition in Percived Relatednessive. (1-Wpr) for personality
    Wpa1 = 0.33;     % Weight of Perceived freedom of action in personal autonomy. (1-Wpa) for
personality
    Wpa2 = 0.33;
    Wpa3 = 0.33;
    alphaPa = 0.9; % Parameter for perceived relatedness and 1-alphaPa) for Affective Valance
    betaPs = 0.5;  % Social support in Perceived support. (1-betaPs) for personality
    gammaSk = 0.5; % Parameter for basic skill and knowledge. (1-alphaSk) for previous experience and
long term persistence
    sigmaSk = 0.5;  % Basic norm (1-betaSk) for knowledge
    Wsk = 0.5;
    pile= 0.5;  % for previous experience in interpretation of experience. (1-gammale) for personality and
skill
    Wie = 0.5;     % personality in interpretation of experience. (1-Wie) for skill

    Wpd1 = 0.5;   % interpretation of experinece in task difficulty
    Wpd2 = 0.5;   % Interview skill
    rhoPc = 0.5;   %weight for self-efficacy in Percieved Competence. (1-rhoPc) for Skill and Interpretation
of experience
    Wg1 = 0.4;      % perceived competency in Goal orientation. (1-Wg) for personal autonomy
    Wg2 = 0.4;
    Wg3 = 0.2;
    psiTt = 0.5;   % weight of personal autonomy in task Specific threat. 1-psiTt) for Long term persistence
    alphaEp = 0.5;  % External parameter PC and PS in Performance Experience. (1-alphaEp)for goal
    Wep = 0.5;

    alphaCv=0.2;
    betaCv = 0.5;  % Goal Orientation in Cognitive valence. (1-betaCv) for performance experience
    Wpc1=0.5;
    Wpc2=0.5;
    lamdaVe = 0.5;  % weight of cognitive valence in Expectatncy value. (1-lamdaVe) for affective valence
    lamdaSm=0.5;
    phiSp = 0.5;  % weight of the sum of self-efficacy and short-term motivation. (1-phiSp) for short-term
persistence
    miuMl=0;

    Delta_t = 0.2; % Change in time
    betaLm = 0.5;  % Accumulative Short term Cognitive Engagement
    alphaLp = 0.5; % Accumulative Short term Persistence
    flag=0;
```

```
% -----------------------    -------------------------------------------------------------------
%DECLARE ALL VARIABLES AND SET initial VALUES TO EXTERNAL factors

% External variables
    Id=zeros(1,numStep); % Interviewer disposition
    Fa=zeros(1,numStep); % Perceived freedom of action
    Ss=zeros(1,numStep); % Social support
    Pn=zeros(1,numStep); % Personality
    Td=zeros(1,numStep); % Task deman
    Pe=zeros(1,numStep); % Previous experience
    Kn=zeros(1,numStep); % Knowledge
    Se=zeros(1,numStep); % Self-efficacy belief

% Instantanious variables
    Pr=zeros(1,numStep); % Perceived relatedness
    Ps=zeros(1,numStep); % Perceived support
    Pd=zeros(1,numStep); % Perceived task difficulty
    Ie=zeros(1,numStep); % Interpretation of experience
    Sk=zeros(1,numStep); % Interview skills
    Pa=zeros(1,numStep); % Perceived personal autonomy
    Go=zeros(1,numStep); % Goal orientation
    Pc=zeros(1,numStep); % Perceived competence
    Sp=zeros(1,numStep); % Short-term persistence
    Tt=zeros(1,numStep); % Task specific threat
    Ep=zeros(1,numStep); % Performance expectancy
    Av=zeros(1,numStep); % Affective valence
    Cv=zeros(1,numStep); % Cognitive valence
    Ve=zeros(1,numStep); % PExpectatncy value
    Sm=zeros(1,numStep); % Short-term motivation

% Temporal variables
    Lm=zeros(1,numStep); % Long-term Motivation
    Lp=zeros(1,numStep); % Long-term Persistence

% Initializing temporal Factors

    Ml(1)=0.1;
    Lp(1)=0.1;

 % initializing external factors
 % creating scenarios
  Scenario=1;
   for t=1:numStep
   switch (Scenario)

     case(1)
       Id(t)=1;
       Fa(t)=1;
       Ss(t)=1;
       Pn(t)=1;
       Td(t)=0.1;
       Pe(t)=0.9;
```

```
        Kn(t)=0.8;
        Se(t)=1;
        SKnorm = 0.9;
    case(2)
        Id(t)=0.9;
        Fa(t)=0.9;
        Ss(t)=0.1;
        Pn(t)=0.2;
        Td(t)=0.8;
        Pe(t)=0.2;
        Kn(t)=0.2;
        Se(t)=0.1;
        SKnorm = 0.2;

   case(3)
        Id(t)=1;
        Fa(t)=1;
        Ss(t)=0.5;
        Pn(t)=0.5;
        Td(t)=0.5;
        Pe(t)=0.5;
        Kn(t)=0.5;
        Se(t)=0.9;
        SKnorm = 0.5;

%    case(4)
%         Ax(t)=0.8;
%         Vp(t)=0.1;
%         Ve(t)=0.1;
%         Me(t)=1;
%         Ss(t)=0.8;
%         Ps(t)=0.8;
%         Td(t)=0.2;
%         SKnorm = 0.8;

  end

  end

% initialize Internal Factors at time, t=1
    t=1;
    Pr(t) = Wpr * Id(t) + (1-Wpr)* Pn(t);
    Pa(t) = alphaPa*(Wpa1*Fa(t) + Wpa2*Pr(t) + Wpa3*Pn(t))+((1-alphaPa)* Av(t));
    Ps(t) = betaPs * Ss(t) + (1-betaPs)* Pn(t);

    Sk(t) = gammaSk * (sigmaSk * SKnorm + (1-sigmaSk)*Kn(t))+(1-gammaSk)*(Wsk*Pe(t)+(1-Wsk)*Lp(t));

    Ie(t) = piIe * Pe(t) + (1-piIe)*(Wie*Pn(t)+(1-Wie)*Sk(t));
    Pd(t) = Td(t)* (1-(Wpd1*Ie(t)+Wpd2*Sk(t)));
    Pc(t) = ((rhoPc*Se(t)+(1-rhoPc)*Sk(t))*Ie(t))*(1-Pd(t));
    Pc(t) = (rhoPc*(Wpc1*Se(t)+ Wpc2*Sk(t))+ (1-rhoPc)*Ie(t))*(1-Pd(t));
    Go(t) = (Wg1*Pc(t) + Wg2*Pa(t) + Wg3*Pd(t))*(1-Tt(t));
```

```
    Tt(t) = Pd(t)* (1 - (psiTt * Pa(t)+(1-psiTt)*Lp(t)));

    %Ep(t) = (alphaEp *(Wep*Pc(t) + (1-Wep)*Ps(t))+(1-alphaEp)*Go(t))*(1-Pd(t));
    Ep(t) = (alphaEp *(Wep*Pc(t) + (1-Wep)*Ps(t))+(1-alphaEp)*(0.5*Go(t)+0.5*Ve(t)))*(1-Pd(t));
    Av(t) = Ep(t)* (1-Tt(t));
    %Cv(t) = betaCv * Go(t) + (1-betaCv) * Ep(t);
    %Cv(t) =(betaCv * Go(t) + (1-betaCv) * Ep(t))+ 0.5*Pd(t);
    Cv(t) = alphaCv*Pd(t) + (1-alphaCv)*(betaCv * Go(t) + (1-betaCv) * Ep(t));
    Ve(t) = lamdaVe * Av(t) + (1-lamdaVe)*Cv(t);
    Sm(t) = lamdaSm*Ve(t) + (1-lamdaSm)*Ep(t);
    Sp(t) = (phiSp * (Se(t) + Sm(t))) * Go(t);

% Run the Model at time, t=2
lamda=0.01;
flag=0;

for t = 2:numStep

    % Instantaneous Factors
    Pr(t) = Wpr * Id(t) + (1-Wpr)* Pn(t);
    Pa(t) = alphaPa*(Wpa1*Fa(t) + Wpa2*Pr(t) + Wpa3*Pn(t))+((1-alphaPa)* Av(t-1));
    Ps(t) = betaPs * Ss(t) + (1-betaPs)* Pn(t);
    Sk(t) = gammaSk * (sigmaSk * SKnorm + (1-sigmaSk)*Kn(t))+(1-gammaSk)*(Wsk*Pe(t)+(1-Wsk)*Lp(t-
1));
    Ie(t) = piIe * Pe(t) + (1-piIe)*(Wie*Pn(t)+(1-Wie)*Sk(t));
    Pd(t) = Td(t)* (1-(Wpd1*Ie(t)+Wpd1*Sk(t)));
    Pc(t) = (rhoPc*(Wpc1*Se(t)+ Wpc2*Sk(t)) + (1-rhoPc)*Ie(t))*(1-Pd(t));
    %Go(t) = ((Wg*Pc(t) + (1-Wg)*Pa(t))*Pd(t))*(1-Tt(t));
    Go(t) = (Wg1*Pc(t) + Wg2*Pa(t) + Wg3*Pd(t))*(1-Tt(t));
    Tt(t) = Pd(t)* (1 - (psiTt * Pa(t)+(1-psiTt)*Lp(t-1)));

    %Ep(t) = (alphaEp *(Pc(t) + Ps(t))+(1-alphaEp)*Go(t))*(1-Pd(t));
    Ep(t) = (alphaEp *(Wep*Pc(t) + (1-Wep)*Ps(t))+(1-alphaEp)*(0.5*Go(t)+0.5*Ve(t-1)))*(1-Pd(t));
   %Ep(t) = (alphaEp *(Wep*Pc(t) + (1-Wep)*Ps(t))+(1-alphaEp)*(Go(t)))*(1-Pd(t));
    Av(t) = Ep(t)* (1-Tt(t));

    Cv(t) = alphaCv*Pd(t) + (1-alphaCv)*(betaCv * Go(t) + (1-betaCv) * Ep(t));
    Ve(t) = (lamdaVe * Av(t) + (1-lamdaVe)*Cv(t));
    Sm(t) = lamdaSm*Ve(t) + (1-lamdaSm)*Ep(t);
    Sp(t) = (phiSp * (Se(t) + Sm(t))) * Go(t);


   % temporal factors

    % Accumulative Short-term motivation

   % Ml(t)= Ml(t-1) + betaMl * ((Ms(t) - Ml(t-1))-lamda)* Ml(t-1) * (1-Ml(t))* Delta_t;
   % Lm?(t+ ?t)=lM(t)+ß_lm.[Pos(Sm(t)-Lm(t)).(1-Lm(t))-Pos(-(Sm(t)-Lm(t)- ?_ml )) .Lm(t)]
    if (Sm(t)-Lm(t)>0)
      Lm(t)=Lm(t-1)+betaLm*(Sm(t)-Lm(t-1))*(1-Lm(t-1))*Delta_t;
    else
      Lm(t)=Lm(t-1)+betaLm*(-(Sm(t)-Lm(t-1)-lamda))*Lm(t-1)*Delta_t;
    end
```

```
    % Accumulative Short-term Peristence
    Lp(t) = Lp(t-1) + alphaLp * (Sp(t)- Lp(t-1))* Lp(t-1) * (1-Lp(t-1)) * Delta_t;
    % z1=Ms(t);
    % z2=Ml(t);
%%      if (flag == 0)
%%
%%         if (Ms(t)-Ml(t)<0.0001)
%%
%%             flag = 1;
%%         end
%%      end
%%      if (flag==1)
%%         lamda=lamda+0.001;
%%      end


end


% plotting graphs
%x = linspace (300,1,500);
hold on
t=1:numStep;
 subplot(2,1,1);
 y=plot(t, Ep,'k-.',t, Ve,'b--');

 xlabel('time steps');ylabel('levels');
 xlim([0 numStep]);ylim([minLimX maxLimY]);
% hold off;
 legend(y,'Performance Expectancy', 'Expectancy Value');
%.........................................................................
 subplot(2,1,2);
 y=plot(t, Sm,'k-.',t, Lm,'b--',t, Lp,'r--');
 xlabel('time steps');ylabel('levels');
 xlim([0 numStep]);ylim([minLimX maxLimY]);

 legend(y,'Motivation ST', 'Motivation LT', 'Persistence LT');
 hold off;
%.........................................................................
```

Appendix I

Simulation Code for Interviewee Anxiety Agent

```
%Intializing all parameters to regulate the equations

    maxLimY = 1;
    minLimX = 0;
    numStep = 500; % 2 hours of interview (120 mins)

    % parameters of Instantanious factors
    phiSw = 0.7;
    sigmaSw=0.5;
    Wcr1 = 0.25; Wcr2= 0.25; Wcr3=0.25; Wcr4=0.25;
    alphaCr=0.5;
    gammaBw = 0.2;
    alphaSy = 0.5;
    betaBw = 0.5;
    psiSw = 0.5;

    % temporal parameters

    Delta_t = 0.2; % Change in time
    Wzx = 0.5;
    betaAp=0.5;   % Accumulative Short term Persistence
    alphaLw=0.5;  % Accumulative Short term worry

% -----------------------    --------------------------------------------------------------------
% -----------------------    --------------------------------------------------------------------
%DECLARE ALL VARIABLES AND SET initial VALUES TO EXTERNAL factors

% External variables
    Rd=zeros(1,numStep); % Percieved Relatedness to the interviewer
    Td=zeros(1,numStep); % Perceived task difficulty
    Se=zeros(1,numStep); % Self-efficacy
    Pe=zeros(1,numStep); % Previous experience
    Pa=zeros(1,numStep); % Percieved personal autonomy
    Ss=zeros(1,numStep); % Social support
    Tr=zeros(1,numStep); % Trait
    Pn=zeros(1,numStep); % Personality

% Instantanious variables
    Sd=zeros(1,numStep); % Situation demand
    Th=zeros(1,numStep); % task specific threat
    Cr=zeros(1,numStep); % Coping resources
    Sy=zeros(1,numStep); % Sensitivity
    Bw=zeros(1,numStep); % Belief about worry
    Sw=zeros(1,numStep); % Short-term worry
    Tc=zeros(1,numStep); % Thought control
```

```
% Temporal variables
    Lw=zeros(1,numStep); % Long-term Motivation
    Ap=zeros(1,numStep); % Long-term Persistence

% Initializing temporal Factors

    Lw(1)=0.2;
    Ap(1)=0.2;

 % initializing external factors
 % creating scenarios

 Scenario=3;

   for t=1:numStep
   switch (Scenario)

     case(1)
        Rd(t)=0.1;
        Td(t)=0.9;
        Se(t)=0.1;
        Pe(t)=0.1;
        Pa(t)=0.1;
        Ss(t)=0.1;
        Tr(t)=0.9;
        Pn(t)=0.1;
    case(2)
        Rd(t)=0.9;
        Td(t)=0.1;
        Se(t)=0.9;
        Pe(t)=0.9;
        Pa(t)=0.9;
        Ss(t)=0.9;
        Tr(t)=0.1;
        Pn(t)=0.9;

    case(3)
        Rd(t)=0.9;
        Td(t)=0.1;
        Se(t)=0.9;
        Pe(t)=0.9;
        Pa(t)=0.9;
        Ss(t)=0.9;
        Tr(t)=0.9;
        Pn(t)=0.1;


   end

   end

% initialize Internal Factors at time, t=1
```

```
    t=1;
    Sd(t)=Td(t)*(1-Rd(t));
    Cr(t)=(Wcr1*Pe(t)+Wcr2*Ss(t)+Wcr3*Se(t)+Wcr4*Pa(t));

    Th(t)=(Sd(t)*(1-Cr(t)));
    Sy(t)=Tr(t)*(1-(alphaSy*(Pn(t))+(1-alphaSy)*Cr(t)));
    Bw(t)=gammaBw*(betaBw*Th(t)+(1-betaBw)*Lw(t))+ (1-gammaBw) * Sy(t);
    Sw(t)=(phiSw*Bw(t)+(1-phiSw)*Th(t))*(1-(psiSw*Cr(t)+(1-psiSw)*Ap(t)));
    Tc(t)=Ap(t)*(1-Lw(t));

%//////////////////////////////////////////////////////////////////////

% Run the Model at time t=2 to last time

for t = 2:numStep

    % Instantaneous Factors
    Sd(t)=Td(t)*(1-Rd(t));
    Cr(t)=(Wcr1*Pe(t)+Wcr2*Ss(t)+Wcr3*Se(t)+Wcr4*Pa(t));

    Th(t)=(Sd(t)*(1-Cr(t)));
    Sy(t)=Tr(t)*(1-(alphaSy*(Pn(t))+(1-alphaSy)*Cr(t)));
    Bw(t)=gammaBw*(betaBw*Th(t)+(1-betaBw)*Lw(t-1))+ (1-gammaBw) * Sy(t);
   % Bw(t)=0.3*(betaBw*Th(t)+(1-betaBw)*Lw(t-1)) + 0.7* Sy(t);
    Sw(t)=(sigmaSw*Bw(t)+(1-sigmaSw)*Th(t))*(1-(psiSw*Cr(t)+(1-psiSw)*Ap(t-1)));
   % Sw(t)=(0.7*Bw(t)+0.3*Th(t))*(1-(psiSw*Cr(t)+(1-psiSw)*Ap(t-1)));
    Tc(t)=Ap(t-1)*(1-Lw(t-1));


   % temporal factors

    % Accumulative Appraisal
    Zx =(Wzx*Cr(t)+(1-Wzx)*Tc(t))*(1-Bw(t))*(1-Sy(t));

    if (Zx-Ap(t-1)>0)
      Ap(t)=Ap(t-1)+ betaAp*((Zx-Ap(t-1))*(1-Ap(t-1)))*Delta_t;
    else
      Ap(t)=Ap(t-1)+ betaAp*((Zx-Ap(t-1))*Ap(t-1))*Delta_t;
    end

    % Accumulative Short-term Worry
    if (Sw(t)-Lw(t-1)>0)
      Lw(t)=Lw(t-1)+ alphaLw * ((Sw(t)-Lw(t-1))*(1-Lw(t-1)))*Delta_t;
    else
      Lw(t)=Lw(t-1)+ alphaLw * ((Sw(t)-Lw(t-1))*Lw(t-1))*Delta_t;
    end


 end
% plotting graphs
%x = linspace (300,1,500);
hold on
t=1:numStep;
```

```
 subplot(2,1,1);
 y=plot(t,Sd,'k-.', t,Th,'b-', t,Cr,'r--',t,Bw,'m--');

 xlabel('time steps');ylabel('levels');
 xlim([0 numStep]);ylim([minLimX maxLimY]);
% hold off;
 legend(y,'sit. demand', 'Threat', 'coping res.','Blv worry');
%.........................................................................
 subplot(2,1,2);
 y=plot(t, Sw,'k-.',t, Lw,'r-',t, Ap,'b--');
 xlabel('time steps');ylabel('levels');
 xlim([0 numStep]);ylim([minLimX maxLimY]);

 legend(y,'ST worry', 'LT Worry', 'Appraisal');
 hold off;
%.........................................................................
```

Appendix J

Simulation Code for Integrated Agent of an Interviewee Mental State

```
%Integrated Model
%Intializing all parameters to regulate the equations
    maxLimY = 1;
   minLimX = 0;
   numStep = 500; % 2 hours of interview (120 mins)
   Delta_t = 0.2; % Change in time
   % parameters of Instantanious factors

 % ********************** ANXIETY **************************

   phiSw = 0.9;
    % Wcr1 = 0.25; Wcr2= 0.25; Wcr3=0.25; Wcr4=0.25;   ^^^^^ ALREADY
   % SPECIFIED IN MOTIVATION
   alphaCr=0.5;
   gammaBw = 0.2;
   alphaSy = 0.5;
   Wbw = 0.5;
   psiSw = 0.1;

   % temporal parameters

   Wzx = 0.1;
   betaAp=0.5;   % Accumulative Short term Persistence
   alphaLw=0.8;  % Accumulative Short term worry

% ********************** ANXIETY *************************
% ***************   MOTIVATION ***************************
   Wpa = 0.5;
   Wcr1=0.25; Wcr2=0.25; Wcr3=0.25; Wcr4=0.25;
   Wpd1=0.5;
   Wpd2=0.5;
   gammaSk = 0.5;
   Wsk=0.5;
   Wg=0.5;

   Wpc1=0.33;
   Wpc2=0.33;
   Wpc3=0.34;
   alphaEp = 0.5;
   Wep = 0.5;
   Wep1 = 0.5;

   alphaCv=0.5;

   lamdaVe = 0.5;
   lamdaSm=0.1;
```

```
    phiSp = 0.5;
    miuMl=0;
    betaLm = 0.5;
    gammaLp = 0.3;
% ********************* MOTIVATION END ******************
% ----------------------SELF-EFFICACY------------------------------------
   Was = 0.5;    % Weight of Anxiety in Affective State. (1-Was) for Basic Efficacy
   Wex = 0.5;    % Experience
   Wei = 0.5; % For Experience in Efficacy information. (1-Wei) for Verbal persuation
   betaBe = 0.8;  % Social support in Basic Efficacy. (1-betaBe) for Mastery Experience
%   gammaSk= 0.5;  % For skill. (1-gammaSk) for Long term persistence
   Wgp1=0.34; Wgp2=0.33; Wgp3=0.33;
    phiGp = 0.5;   % inner factors for personal goal. (1-phiGp) for progress towards goal
    rhoGp = 0.5;   % Basic efficacy in Personal Goal. (1-rhoGp) for Mastery experience
    Wsp1 = 0.25;    % weight of Basic Efficacy in Short-Term Persistence.
    Wsp2 = 0.25;    % weight of short-term engagement in Short-Term Persistence.
    Wsp3 = 0.25;    % weight of goal in Short-Term Persistence.
    Wsp4 = 0.25;    % weight of long-term efficacy in Short-Term Persistence.
    betaSe = 0.5;  % Internal factors [Be, Sp]of Short-Term engagement. (1-betaSe) for external factors [Pg,Gf].
    Wse1 = 0.5;      % Basic Efficacy in Short-Term Cognitive engagement. (1-Wse1) for short term persistence
    Wse2 = 0.5;    % Progress towards goal in Short-Term Cognitive engagement. (1-Wse2) for Generated effort
    alphaEa = 0.5; % Internal factors [Ei, Gp]of Efficacy appraisal. (1-alphaEa) for external factors [Le,Mf].
    Wea1 = 0.8;    % Efficacy information in Efficacy Appraisal. (1-Wea1) for personal goal
    Wea2 = 0.5;    % Long-term cognitive engagement in Efficacy Appraisal. (1-Wea2) for Mental effort
    gammaMf = 0.5; % External factors [Gp, Gf]of mental Effort. (1-gammaMf) for internal factor [Be].
    psiMf = 0.5;   % Personal goal in Mental Effort. (1-psiMf) for Generated effort.
    Wgf = 0.5;     % Mental effort in Generated effort. (1-Wgf) for short-term efficacy
    Wpg1 = 0.33;    % Short-term efficacy in Progress towards goal
    Wpg2 = 0.33;    % Long-term persistence in Progress towards goal
    Wpg3 = 0.33;    % Mental effort in Progress towards goal
    lamdaSf = 0.2; % Internal factors [Be, Ea, Lp]of Short-term Efficacy. (1-lamdaSf) for external factors [Gp].
    Wsf1 = 0.33;    % Basic efficacy in short-term efficacy
    Wsf2 = 0.33;    % Efficacy appraisal in short-term efficacy
    Wsf3 = 0.33;    % Long term persistence in short-term efficacy
    Wlp = 0.5;     % sgot termpersistence in long term persistence. (1-wlp) for

    betaLe = 0.9;  % Accumulative Short term Cognitive Engagement
    alphaLp = 0.9; % Accumulative Short term Persistence
   % gammaSf = 0.9; % Short term efficacy
    gammaLf = 0.9; % Accumulative Short term Self Efficacy
 % ----------------------SELF-EFFICACY ENDS-------------------------------

%DECLARE ALL VARIABLES AND SET initial VALUES TO EXTERNAL factors
% External variables
  %=========== aNXIETY =========
    Rd=zeros(1,numStep); % dEFINED ALREADY
    Td=zeros(1,numStep); % dEFINED ALREADY
    Sef=zeros(1,numStep); % dEFINED ALREADY
    Pe=zeros(1,numStep); % dEFINED ALREADY
```

```
    Pa=zeros(1,numStep); % dEFINED ALREADY
    Ss=zeros(1,numStep); % dEFINED ALREADY
    Tr=zeros(1,numStep); % Trait
    Pn=zeros(1,numStep); % Personality

  %=========== mOTIVATION =========
   % Pa=zeros(1,numStep);
   % Rd=zeros(1,numStep);
   % Ss=zeros(1,numStep);
   % Td=zeros(1,numStep);
   % Pe=zeros(1,numStep);
   % Se=zeros(1,numStep);

 %=========== sELF-EFFICACY=========
    Ax=zeros(1,numStep); % Anxiety - Arousal interpretation
    Vp=zeros(1,numStep); % Verbal persuasion
    Vx=zeros(1,numStep); % Vicarious experience
   % Me=zeros(1,numStep); % Mastery experience-dEFINED AS PRIOR EXPERINCE
   % Ss=zeros(1,numStep); % Social support - dEFINED ALREADY
   % Ps=zeros(1,numStep); % Personality
   % Td=zeros(1,numStep); % Task Demand

  % Instantanious variables

    Lp=zeros(1,numStep);
  %=========== mOTIVATION =========
    Sd=zeros(1,numStep);
    Cr=zeros(1,numStep);
    Pd=zeros(1,numStep);
    Sk=zeros(1,numStep);
    Th=zeros(1,numStep);
    Gl=zeros(1,numStep);
    Pc=zeros(1,numStep);
    SpM=zeros(1,numStep);
    Ep=zeros(1,numStep);
    Av=zeros(1,numStep);
    Cv=zeros(1,numStep);
    Ve=zeros(1,numStep);
    Sm=zeros(1,numStep);
%=========== aNXIETY =========
   % Sd=zeros(1,numStep); % dEFINED ALREADY
   % Th=zeros(1,numStep); % dEFINED ALREADY
   % Cr=zeros(1,numStep); % dEFINED ALREADY
    Sy=zeros(1,numStep); % Sensitivity
    Bw=zeros(1,numStep); % Belief about worry
    Sw=zeros(1,numStep); % Short-term worry
    Tc=zeros(1,numStep); % Thought control
%=========== sELF-EFFICACY =========
    As=zeros(1,numStep); % Affective state
    Ex=zeros(1,numStep); % Experience
    Ei=zeros(1,numStep); % Efficacy Information
    Be=zeros(1,numStep); % Basic Efficacy
   % Pd=zeros(1,numStep); % Percieved Task Difficulty
```

```
  % Sk=zeros(1,numStep); % Skill
    Gp=zeros(1,numStep); % Personal Goal
    SpE=zeros(1,numStep); % Short-term persistence
    Se=zeros(1,numStep); % Short-term congitive engagement
    Ea=zeros(1,numStep); % Efficacy appraisal
    Mf=zeros(1,numStep); % Mental Effort
    Gf=zeros(1,numStep); % Generated Effort
    Pg=zeros(1,numStep); % Progress towards Goal
    Sf=zeros(1,numStep); % Short-term Self Efficacy

% Temporal variables
  %=========== mOTIVATION =========
    Lm=zeros(1,numStep);
    LpM=zeros(1,numStep);
 %=========== aNXIETY =========
    Lw=zeros(1,numStep);
    Ap=zeros(1,numStep);
 %=========== sELF-EFFICACY =========
    LpE=zeros(1,numStep); % Long-term Persistence
    Le=zeros(1,numStep); % Long-term cognitive engagement
    Lf=zeros(1,numStep); % Long-term Self Efficacy
% Initializing temporal Factors
   %=========== aNXIETY =========
    Lw(1)=0.0;
    Ap(1)=0.2;
%     Lw(1)=0.3;
%     Ap(1)=0.3;
 %=========== mOTIVATION =========
    Lm(1)=0.0;
    LpM(1)=0.1;

%     Lm(1)=0.2;
%     LpM(1)=0.2;
 %=========== sELF-EFFICACY =========
    LpE(1)=0.3;
    Le(1)=0.3;
    Lf(1)=0.1;
%     LpE(1)=0.1;
%     Le(1)=0.1;
%     Lf(1)=0.1;
% creating scenarios
Scenario=1;
  for t=1:numStep
  switch (Scenario)
    case(1)
       Pe(t)=0.2;
       Vx(t)=0.2;
       Pa(t)=0.4;
       Pn(t)=0.4;
       Ss(t)=0.5;
       Tr(t)=0.8;
       Td(t)=1;
       Vp(t)=0.3;
```

```
        Rd(t)=0.1;

        SKnorm = 0.1;

      case(2)
        Pa(t)=0.1;
        Rd(t)=0.1;
        Ss(t)=0.1;
        Td(t)=0.9;
        Pe(t)=0.1;
        SKnorm = 0.1;

        Tr(t)=0.9;
        Pn(t)=0.1;

        Vp(t)=0.1;
        Vx(t)=0.1;

     case(3)
        Pa(t)=0.9;
        Rd(t)=0.9;
        Ss(t)=0.9;
        Td(t)=0.1;
        Pe(t)=0.9;
        SKnorm = 0.8;
        Tr(t)=0.2;
        Pn(t)=0.9;
        Vp(t)=0.9;
        Vx(t)=0.9;

     case(4)
        Pa(t)=0.1;
        Rd(t)=0.1;
        Ss(t)=0.1;
        Td(t)=0.9;
        Pe(t)=0.1;
        SKnorm = 0.1;

        Tr(t)=0.1;
        Pn(t)=0.9;

        Vp(t)=0.1;
        Vx(t)=0.1;
    end

    end

% initialize Internal Factors at time, t=1
    t=1;
  %=========== mOTIVATION =========
   Pa(t) = Wpa*Pa(t) + (1-Wpa)* Av(t);
   Sd(t) = Pd(t)*(1-Rd(t));
   Cr(t)= Wcr1*Pe(t)+Wcr2*Ss(t)+Wcr3*Be(t)+Wcr4*Pa(t);
```

```
    Sk(t) = gammaSk * SKnorm + (1-gammaSk)*(Wsk*Pe(t)+(1-Wsk)*Lp(t));
    Pd(t)=Td(t)*(1-(Wpd1*Pe(t)+Wpd2*Sk(t)));
    Th(t)=Sd(t)*(1-Cr(t));
    Pc(t)=Wpc1*Cr(t)+Wpc2*Sk(t)+Wpc3*Pe(t);
    Gl(t)= (Pc(t)+Pd(t))*(1-Th(t));
          Ep(t) = (alphaEp *(Wep*Pc(t) + (1-Wep)*Cr(t))+(1-alphaEp)*(Wep1*Gl(t)+ (1-
Wep1)*Ve(t)));%*(1-Pd(t));
    Av(t) = Ep(t)* (1-Th(t));
    Cv(t) = alphaCv*Pd(t) + (1-alphaCv)*(Gl(t)+ Ep(t))*LpM(t);
    Ve(t) = lamdaVe * Av(t) + (1-lamdaVe)*Cv(t);
    Sm(t) = lamdaSm*Ve(t) + (1-lamdaSm)*Ep(t);
    SpM(t) = (phiSp * Se(t) + phiSp*Sm(t)) * Gl(t);

  %============ aNXIETY ==============================================

  %  Sd(t)=Td(t)*(1-Rd(t));        dEFINED ALREADY
  %  Cr(t)=(Wcr1*Pe(t)+Wcr2*Ss(t)+Wcr3*Se(t)+Wcr4*Pa(t));dEFINED ALREADY
  %  Th(t)=(Sd(t)*(1-Cr(t))); dEFINED ALREADY
     Sy(t)=Tr(t)*(1-(alphaSy*(Pn(t))+(1-alphaSy)*Cr(t)));
     Bw(t)=gammaBw*(Wbw*Th(t)+(1-Wbw)*Lw(t))+ (1-gammaBw) * Sy(t);
     Sw(t)=(phiSw*Bw(t)+(1-phiSw)*Th(t))*(1-(psiSw*Cr(t)+(1-psiSw)*Ap(t)));
     Tc(t)=Ap(t)*(1-Lw(t));

 %============ sELF-EFFICACY ==========================================

     Be(t) = (betaBe * Ss(t) + (1-betaBe)* Pe(t)) * Pn(t);
     As(t) = Lw(t) * (1-Be(t));
     Ex(t) = Wex * Pe(t) + (1-Wex)*Vx(t);
     Ei(t) = (Wei * Ex(t) + (1-Wei) * Vp(t)) * (1 - As(t));

     Gp(t)=  (Wgp1*Be(t)+Wgp2*Pe(t)+Wpg3*Pg(t))*(1-Pd(t));
     Se(t) = betaSe * (Wse1*Be(t)+(1-Wse1) * Sk(t)) + (1-betaSe) * (Wse2*Pg(t) + (1-Wse2)*Gf(t));

     SpE(t) = Wsp1 * Lm(t) + Wsp2*Se(t) + Wsp3*Gp(t) + Wsp4*Lf(t);

     Ea(t) = alphaEa * (Wea1*Ei(t) + (1-Wea1)*Gp(t)) + (1-alphaEa) * (Wea2*Le(t) + (1-Wea2)*Mf(t));
     Gf(t) = Wgf * Mf(t) + (1-Wgf) * Sf(t);
     Mf(t) = gammaMf * (psiMf*Gp(t) + (1-psiMf)*Gf(t)) + (1-gammaMf)*Be(t);

     Pg(t) = Wpg1 * Sf(t) + Wpg2 * LpE(t) + Wpg3 * Mf(t);
     Sf(t) = lamdaSf * (Wsf1*Gp(t) + Wsf2*Ea(t) + Wsf3*LpE(t)) + (1-lamdaSf)*Be(t);


    % ###########################################################################
     Lp(t) = 0.5*LpM(t) + 0.5*LpE(t);

% Run the Model at time, t=2
lamda=0.01;
flag=0;

for t = 2:numStep

     % Instantaneous Factors
```

```
%============ mOTIVATION ==========
  Pa(t) = Wpa*Pa(t) + (1-Wpa)* Av(t-1);
  Sd(t)=Td(t)*(1-Rd(t));
  Cr(t)= Wcr1*Pe(t)+Wcr2*Ss(t)+Wcr3*Be(t-1)+Wcr4*Pa(t);
  Pd(t)=Td(t)*(1-(Wpd1*Pe(t)+Wpd2*Sk(t)));
  Sk(t) = gammaSk * SKnorm + (1-gammaSk)*(Wsk*Pe(t)+(1-Wsk)*Lp(t-1));
  Th(t)=Sd(t)*(1-Cr(t));
  Pc(t)=Wpc1*Cr(t)+Wpc2*Sk(t)+Wpc3*Pe(t);
  Gl(t)= (Pc(t)+Pd(t))*(1-Th(t));
        Ep(t) = (alphaEp *(Wep*Pc(t) + (1-Wep)*Cr(t))+(1-alphaEp)*(Wep1*Gl(t)+ (1-Wep1)*Ve(t-1)));%*(1-Pd(t));
  Av(t) = Ep(t)* (1-Th(t));
  Cv(t) = alphaCv*Pd(t) + (1-alphaCv)*(Gl(t)+ Ep(t))*Lp(t-1);
  Ve(t) = lamdaVe * Av(t) + (1-lamdaVe)*Cv(t);
  Sm(t) = lamdaSm*Ve(t) + (1-lamdaSm)*Ep(t);
  SpM(t) = (phiSp * Se(t) + phiSp*Sm(t)) * Gl(t);
  % temporal factors
   if (Sm(t)-Lm(t)>0)
     Lm(t)=Lm(t-1)+betaLm*(Sm(t)-Lm(t-1))*(1-Lm(t-1))*Delta_t;
   else
     Lm(t)=Lm(t-1)+betaLm*(-(Sm(t)-Lm(t-1)-lamda))*Lm(t-1)*Delta_t;
   end

   LpM(t) = Lp(t-1) + gammaLp * (SpM(t)- LpM(t-1))* LpM(t-1) * (1-LpM(t-1)) * Delta_t;

 %============ aNXIETY ====================================================
 %  Sd(t)=Td(t)*(1-Rd(t));        dEFINED ALREADY
 %  Cr(t)=(Wcr1*Pe(t)+Wcr2*Ss(t)+Wcr3*Se(t)+Wcr4*Pa(t)); dEFINED ALREADY
 %  Th(t)=(Sd(t)*(1-Cr(t)));      dEFINED ALREADY
   Sy(t)=Tr(t)*(1-(alphaSy*(Pn(t))+(1-alphaSy)*Cr(t)));
   Bw(t)=gammaBw*(Wbw*Th(t)+(1-Wbw)*Lw(t-1))+ (1-gammaBw) * Sy(t);
   Sw(t)=(phiSw*Bw(t)+(1-phiSw)*Th(t))*(1-(psiSw*Cr(t)+(1-psiSw)*Ap(t-1)));
   Tc(t)=Ap(t-1)*(1-Lw(t-1));

% temporal factors
  Zx =(Wzx*Cr(t)+(1-Wzx)*Tc(t))*(1-Bw(t))*(1-Sy(t));

   if (Zx-Ap(t-1)>0)
     Ap(t)=Ap(t-1)+ betaAp*((Zx-Ap(t-1))*(1-Ap(t-1)))*Delta_t;
   else
     Ap(t)=Ap(t-1)+ betaAp*((Zx-Ap(t-1))*Ap(t-1))*Delta_t;
   end
   if (Sw(t)-Lw(t-1)>0)
     Lw(t)=Lw(t-1)+ alphaLw * ((Sw(t)-Lw(t-1))*(1-Lw(t-1)))*Delta_t;
   else
     Lw(t)=Lw(t-1)+ alphaLw * ((Sw(t)-Lw(t-1))*Lw(t-1))*Delta_t;
   end
%============== sELF-EFFICACY ==============================================
  Be(t) = (betaBe * Ss(t) + (1-betaBe)* Pe(t)) * Pn(t);
  As(t) = Lw(t) * (1-Be(t));
  Ex(t) = Wex * Pe(t) + (1-Wex)*Vx(t);
  Ei(t) = (Wei * Ex(t) + (1-Wei) * Vp(t)) * (1 - As(t));
  %Sk(t)= gammaSk * SKnorm + (1 - gammaSk) * Lp(t); TAKEN CARE OF
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```
  %Pd(t)= Td(t) * (1-Sk(t));
 Gp(t)=  (Wgp1*Be(t)+Wgp2*Pe(t)+Wpg3*Pg(t-1))*(1-Pd(t));
% Gp(t)= phiGp * ((rhoGp*Be(t)+(1-rhoGp)*Pe(t))*(1-Pd(t)))+(1-phiGp)* Pg(t);

% SpE(t) = Wsp1 * Be(t) + Wsp2*Se(t) + Wsp3*Gp(t) + Wsp4*Lf(t);

 Se(t) = betaSe * (Wse1*Be(t)+(1-Wse1) * Sk(t)) + (1-betaSe) * (Wse2*Pg(t-1) + (1-Wse2)*Gf(t-1));
 SpE(t) = Wsp1 * Lm(t) + Wsp2*Se(t) + Wsp3*Gp(t) + Wsp4*Lf(t-1);
 Ea(t) = alphaEa * (Wea1*Ei(t) + (1-Wea1)*Gp(t)) + (1-alphaEa) * (Wea2*Le(t-1) + (1-Wea2)*Mf(t-1));
 Gf(t) = Wgf * Mf(t-1) + (1-Wgf) * Sf(t-1);
 Mf(t) = gammaMf * (psiMf*Gp(t) + (1-psiMf)*Gf(t)) + (1-gammaMf)*Be(t);
 Pg(t) = Wpg1 * Sf(t-1) + Wpg2 * LpE(t-1) + Wpg3 * Mf(t);
 Sf(t) = lamdaSf * (Wsf1*Gp(t) + Wsf2*Ea(t) + Wsf3*LpE(t-1)) + (1-lamdaSf)*Be(t);
% temporal factors
  Le(t)= Le(t-1) + betaLe * (Se(t) - Le(t-1))* Le(t-1) * (1-Le(t-1))* Delta_t;
  LpE(t) = LpE(t-1) + alphaLp * (SpE(t)- LpE(t-1))* LpE(t-1) * (1-LpE(t-1)) * Delta_t;
  Lf(t) = Lf(t-1) + gammaLf * (Sf(t) - Lf(t-1)) * Lf(t-1) * (1-Lf(t-1)) * Delta_t;

%=========== working variable computation=========
 Lp(t) = 0.5*LpM(t) + 0.5*LpE(t);

end
% plotting graphs
%x = linspace (300,1,500);
hold on
t=1:numStep;
 %subplot(3,1,1);
 y=plot(t,Lw,'b-', t, Lm, 'k-', t, Lf, 'r-');
 %y=plot(t, Ap,'m-.',t, Lw,'b--', t, LpM, 'k--',t, Lm, 'g-', t, Le, 'k-', t, LpE, 'b-', t, Lf, 'r-');
 xlabel('time steps');ylabel('levels');
 xlim([0 numStep]);ylim([minLimX maxLimY]);
% hold off;
 legend(y,'Anxiety', 'Motivation','Self-efficacy');
 %legend(y,'Appraisal', 'Anxiety', 'Persistence(M)', 'Motivation','Engagement','Persistence (F)', 'Self-efficacy');
%.........................................................................
%  subplot(3,1,2);
%  y=plot(t, Sm,'k-.',t, Lm,'b--',t, LpM,'r--');
%  xlabel('time steps');ylabel('levels');
%  xlim([0 numStep]);ylim([minLimX maxLimY]);
%
%  legend(y,'Motivation ST', 'Motivation LT', 'Persistence LT');
%
% %.........................................................................
%  subplot(3,1,3);
%  y=plot(t, Le,'k-.',t, LpE,'b--',t, Lf,'r--');
%  xlabel('time steps');ylabel('levels');
%  xlim([0 numStep]);ylim([minLimX maxLimY]);
%
%  legend(y,'Engagement ST', 'Persistence LT', 'Efficacy LT');

 hold off;
%.........................................................................
```